Innovation in Services. Overview of Data Sources and Analytical Structures

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CONTENTS

1. INTRODUCTION

In most industrialised countries services presently account for the major share of output and employment in the economy. Service industries are also considered to be a major engine of employment growth. However, otherwise the picture is varied. Some service industries have experienced substantial output growth and/or productivity growth, but in other cases service activities have contributed to the productivity slowdown of advanced economies. In some service industries innovative activities is one of the driving factors behind the expansion process, but in other industries product market restrictions reduce the innovative capabilities. Still service innovations are ubiquitous, *i.e.* new services and service formulas – such as new software, customisation and upgrading of existing software – spring up everywhere. Moreover, existing services are frequently "re-engineered" partly under the influence of changing market forces and shifts in consumer demand.

Unfortunately, compared with manufacturing industries, the knowledge and the provision of information about the role of innovation in services are lagging behind. This is the main motivation behind the project '*Structurele Informatievoorziening Innovatie in Diensten*' (SIID), initiated by the General Technology Policy (ATB) directorate of the Dutch Ministry of Economic Affairs. The major aims of the SIID project are (1) to construct a data base with (internationally comparable) data on service innovation; (2) to carry out a number of thematic essays on service innovation; and (3) to present papers on policy-related issues concerning service innovation. The latter two types of products are meant to benefit from the database mentioned under (1).

This paper deals with the construction of the SIID database (item 1). Together with an accompanying thematic paper on the conceptualisation of service innovation, it concludes the first phase of the SIID project. The present paper has a twofold aim. Firstly, it presents an overview of sources of data on service innovation. We distinguish two levels of data, namely data at the macro-level and data at the micro level.[1] Data at the macro-level are mainly obtained from primary and secondary statistical sources produced by national and international (statistical) agencies. Most macro-data do not measure the service innovation process itself, but mainly represent inputs in or output originating from the innovation process. Data at the micro-level are derived from specific innovation surveys of firms and enterprises, which have been carried out over the past decade, and cover – although to a limited extent – service sectors as well. Section 2 provides an overview of macro and micro

[1] The third level, namely sector-specific data that focus on particular innovations in specified service industries, is addressed in the companion paper by den Hertog and Bilderbeek (1999).

indicators on service innovation, and it discusses the strengths and weaknesses of the various measures.

The second aim of the paper is to provide analytical structures that can assist in analysing the data. The main characteristic of the analytical structures vis-à-vis the raw data, is that analytical structures require constructs and assumptions on the relation between the various indicators in the database. At the macro-level we propose two structures, namely a productivity accounting system, which allows to analyse the contribution of the inputs in the production process, including skilled and unskilled labour, different vintages of physical equipment and technology inputs, to the output produced. Secondly, we discuss an input-output accounting framework to analyse backward linkages of intermediate input use in service industries. The input-output structure may also serve a more detailed analysis of innovation relations between industries, using R&D data. At the micro level we compare the statistical computer package, LISREL (Linear Structural Relations), as a means to analyse the data from micro-based innovation surveys with regular regression analysis, which is mostly used fo this purpose. Section 3 describes these analytical structures in more detail. At the present stage we have only carried out small experiments with LISREL to test its feasibility. In the next stages of the SIID project, more elaborate analyses will be developed, and the results will be reproduced in thematic and policy papers that follow.

2. OVERVIEW OF DATA SOURCES

2.1 Structure of SIID Database

The pilot study for the SIID project by Den Hertog *et al.* (1997) present a systematic and detailed overview of indicators – including their main sources of information – that can be applied for the measurement of innovative activities in service industries. Furthermore, they provide the outline of the structure for the SIID database.

The structure of the SIID database is based on a matrix that represents two dimensions. The first dimension refers to the concept of National Innovation Systems. In this dimension innovation is regarded as a dynamic process which is carried out within a network of intensive interaction. Hence, the success of the innovation process is crucially dependent on the way in which the inputs in the innovation process are transformed into outputs, which is referred as the “throughput” process. The second dimension makes a more practical distinction according to level of disaggregation of the unit of analysis: macro, meso and micro. To some extent, this classification is ambiguous and a possible source of confusion. “Meso” may refer to 2- or 3-digit branches in services or to more refined 4-digit industries.

"Micro" may refer to relations between firms within an industry or to relations within firms. For this reason we distinguish only two levels in this paper. At the macro level we focus on indicators which are provided for aggregated branches or industries through primary or secondary statistical sources. At the micro level we deal with innovation indicators for individual firms, which are derived from micro surveys such as the Community Innovation Surveys.

The indicators at macro and micro level only deal with general innovation indicators; *i.e.* the type of information is collected irrespective of the sector or industry. The meso level refers to more elaborate branch-specific effects instead of simple sectoral effects. Separately, specific indicators will also be collected for six selected service industries: wholesale trade, retail trade, transport, technical engineering, financial services, and temporary work industry.[2]

2.2 Macro Level Indicators

This section introduces macro indicators that represent input in or output from the innovation process, and input-output coefficients from the input-output tables that show throughput.

Output, Employment and Productivity

Over the past 25 years the share of services in output and employment has substantially increased. Figure 1 shows that the total share of services output for the European countries increased between 10 and 15 % -points between 1973 and 1996, and for the United States by 7 %-points. In 1996 total services output in these five countries accounted for approximately 65% of total output. When looking in more detail at the five major service sectors in 1996, some important differences between the countries arise. Firstly, Germany[3] is characterised by a relatively large output share for "community, social and personal services" (indicated as "other non-government"), which is due to an important difference in industry classification. Germany's official statistics classify business services as part of this sector rather than as part of the finance and business services sector, as other countries have done.[4] Another important difference between the countries is the relatively large output share of trade in The Netherlands and the United States. In The Netherlands this is mainly related to the large external sector of the Dutch economy, so that wholesale trade accounts for a relatively large output share. For the United States, retail activities have undergone a substantial expansion over the past 25 years.

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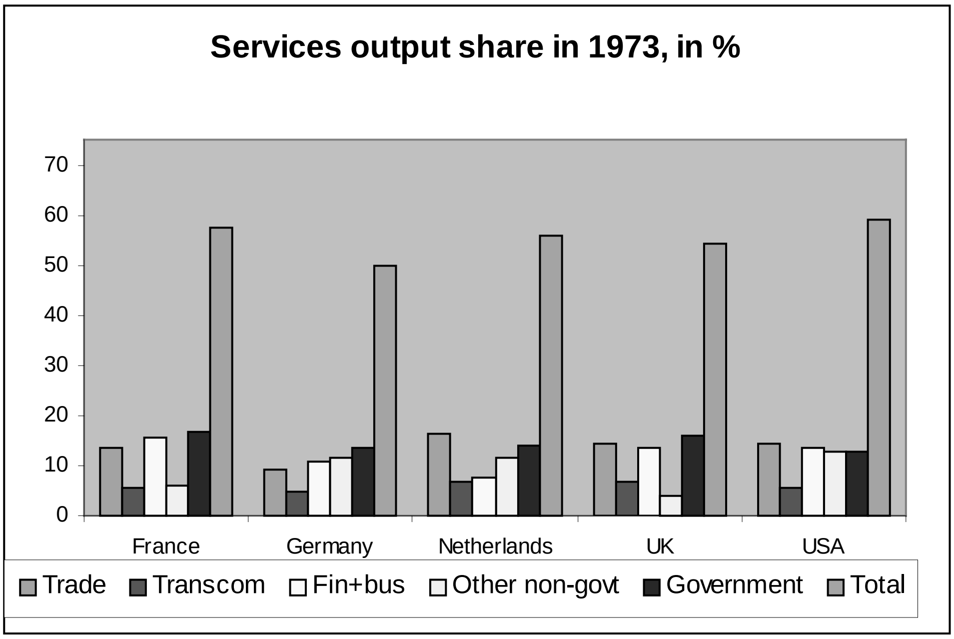
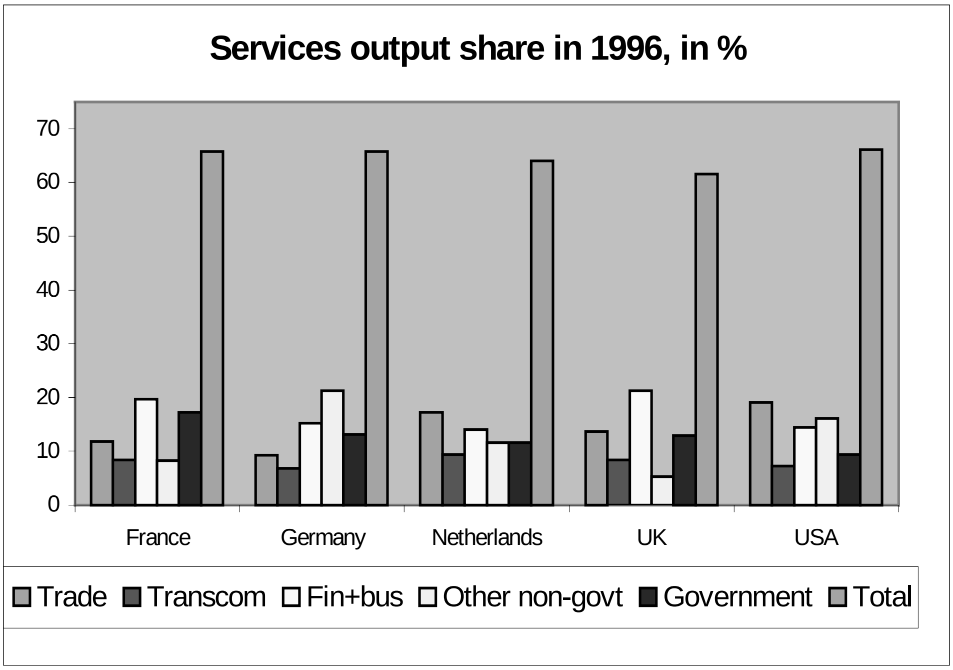
[2] See the companion paper by den Hertog and Bilderbeek (1999) for more detail.
[3] Germany in this paper refers to West Germany only.
[4] So far it has appeared impossible to find secondary sources in order to split business services from other market services in Germany (see also O'Mahony, 1999)

Figure 1 – %-Shares of Services in Total Output, 1973 and 1996

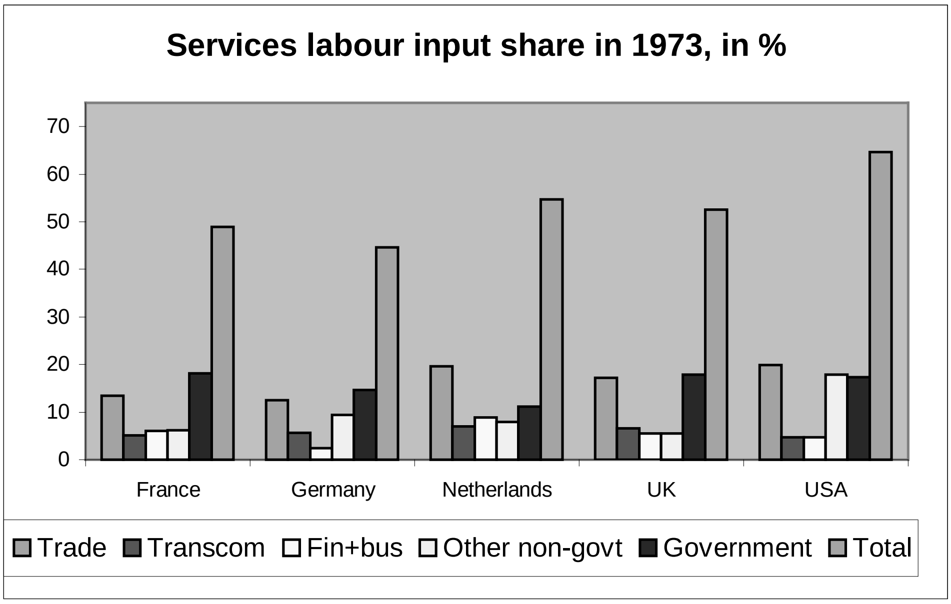


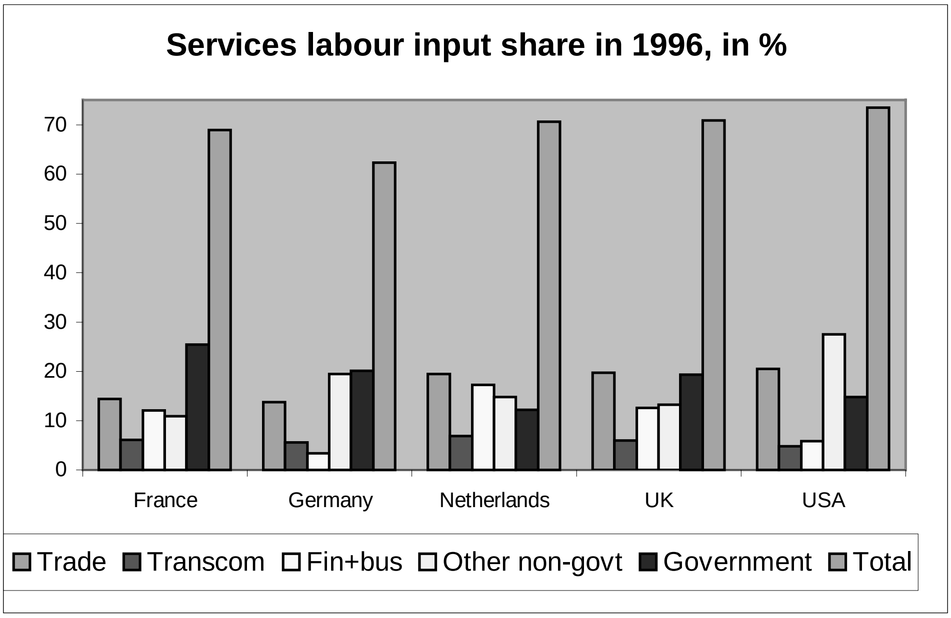


Note: output share is measured on the basis of GDP at constant prices

Source: Groningen Growth and Development Centre, Sectoral Database; see annex A.

Figure 2 – %-Shares of Services in Total Hours Worked, 1973 and 1996





Note: labour input share is measured on the basis of total hours worked
Source: Groningen Growth and Development Centre, Sectoral Database; see annex A

Figure 2 shows that the increase in service labour input share in the total economy has been largest for finance and business services and other non-government services. In the European countries hours worked in total services as a share of labour input of the whole economy has increased faster than the output share of services. This suggests a slower rise in labour productivity (output per hour) in services than for the total economy. Indeed between 1973 and 1996 the average annual productivity growth rate for services in France was 0.9 %-point lower than for the total economy, in the UK 0.7 %-points lower, in The Netherlands 0.5 %-points lower, in Germany 0.3 %-points lower, and in the USA only 0.1 %-point lower (see also Table 1).

Table 1. - Average Annual Compound Growth Rate of GDP per hour and %-Point Contribution of Service Sectors to Average Annual Growth of Labour Productivity (between parentheses), 1973-85 and 1985-1996.

		Wholesale and Retail Trade	Transport and Communi-cation	Finance, Insurance Real Estate & Business Services	Community, Social and Personal Services	Government Services	Total Service Sector	Total Economy
		%	%	%	%	%	%	%
		Average annual compound growth rate (%-point contribution to growth rate of total economy)						
France	1973-1985	2.5 (10)	3.8 (6)	1.4 (3)	2.3 (5)	2.0 (12)	2.4 (35)	3.5 (100)
	1985-1996	1.0 (8)	3.9 (14)	-0.1 (-1)	0.7 (4)	0.6 (8)	1.0 (33)	1.8 (100)
Germany	1973-1985	2.1 (9)	4.4 (9)	3.1 (3)	1.8 (7)	1.0 (6)	2.3 (34)	2.9 (100)
	1985-1996	2.1 (12)	3.8 (9)	2.6 (3)	2.4 (17)	1.1 (10)	2.4 (52)	2.3 (100)
The Netherlands	1973-1985	3.6 (25)	4.0 (10)	3.9 (15)	-1.0 (-4)	0.5 (2)	2.2 (49)	2.7 (100)
	1985-1996	1.1 (15)	3.1 (16)	-0.1 (-1)	-0.3 (-3)	1.4 (14)	0.8 (41)	1.3 (100)
United Kingdom	1973-1985	0.6 (4)	2.7 (8)	1.2 (4)	0.3 (1)	0.8 (6)	1.3 (23)	2.3 (100)
	1985-1996	2.4 (21)	4.6 (13)	0.0 (0)	-0.6 (-3)	1.2 (11)	1.7 (42)	2.2 (100)
United States	1973-1985	2.2 (42)	2.4 (10)	-0.4 (-2)	0.7 (14)	0.7 (11)	1.2 (75)	1.1 (100)
	1985-1996	2.0 (41)	1.8 (8)	1.3 (8)	-0.5 (-12)	0.2 (4)	0.7 (48)	1.0 (100)

Note: productivity growth rates by sector are weighted at the arithmetic average of the share of labour input in the total economy at the beginning and at the end of the period. Business services in Germany are included in "Community, social and personal services".

Source: Groningen Growth and Development Centre Sectoral Database; see Annex A.

Table 1 shows the productivity growth rates by service sector and the contribution of individual service sectors to overall growth in labour productivity. In many countries service productivity growth rates have fallen or remained flat comparing the period 1985-1996 to the period 1973-1985. The only notable exceptions are community, social and personal services in Germany, which in the German case includes business services, government services in The Netherlands and the UK, trade and transport and communication services in the UK, and the finance and business services in the United States.

Nevertheless, only for the United States a very clear relationship exists between the productivity slowdown in services and that for the total economy. Between 1973 and 1985 the contribution of services to overall productivity growth in the U.S. was 75 per cent, which declined to 48 per cent during the period 1985-1996. This declining contribution was in particular due to the sharply negative contribution of "other non-government services" to productivity growth. In The Netherlands the contribution of services to labour productivity growth also declined from about 50% to 40% when comparing the periods 1973-1985 and 1985-1996. This is in particular due to the fall in contribution from trade and from finance and business services. However, in Germany and the United Kingdom, the contribution of services to labour productivity growth increased substantially. In Germany "other non-government services" (including business services) contributed strongly to productivity growth, and in the UK the contribution of productivity growth in the trade sector increased substantially. With the exception of France, the percentage contributions of productivity of all services to productivity growth of the total economy are now fairly similar across the countries. Services contribute 40% to 50% to the national productivity growth rate.

Productivity and output measures in services are seriously affected by measurement problems. [5] These problems are firstly due to the increased diversity of output and inputs in the sector, which is related to the greater heterogeneity of services, more direct customer-client interface, and increased emphasis on after-sales services. Secondly (but related to the first category of problems) there are statistical problems, such as the difficulty in splitting the growth of the value of services into a price, quantity and quality component. For example, the slowdown in (or even negative) productivity growth in banking sector in many countries maybe largely due to measurement problems. Traditionally, real output growth in banking has been calculated on the basis of the sum of the real value of intermediate inputs and labour cost, thus implicitly imposing productivity growth on the output indicators. Recent experimental calculations by Statistics Netherlands, based on weighted volume indicators of banking services, which represent interest margins and procuration, suggest a rise in labour productivity in the banking sector of 3.6 per cent per year over the period 1987-1995 (CBS, 1997, Hogenboom and van de Ven, 1998). However, not all services are as seriously affected by measurement problems as the finance sector. For example, a recent study on productivity in business services in The Netherlands concluded that measurement problems are less serious as the trends in productivity and profitability match reasonably well, which might be expected when assuming perfect markets without rent-sharing (van der Wiel, 1999).

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[5] See *e.g.* Baily and Gordon (1988), Griliches (1992), Diewert and Fox (1999), and McGuckin and Stiroh (1999).

Apart from comparing productivity trends, labour productivity may also be compared in terms of relative levels. For this purpose one not only requires information on output values and labour input by sector, but also sector-specific purchasing power parities to convert output to a common currency. Over the past decade the University of Groningen has carried out substantive research on productivity level comparisons, which has subsequently been implemented by other research groups across Europe.

Table 2 compares relative levels of output per person employed in the transport industry. The table shows that the productivity performance of the transport sector in Netherlands was above that of the United States, whereas French, German, and UK levels were substantially below the U.S. levels. The results for the individual transport industries show a substantial variation. For example, in most countries productivity relative to the USA was low in rail and road transport, namely 81 per cent for France, 64 per cent for Germany and 55 per cent for the UK. The lower productivity is partly related to the much greater share of passenger transportation compared to freight transportation in railways in all European countries relative to the USA. Productivity in passenger rail transport is usually lower than in freight rail transport, because the former is more labour intensive (it requires support staff, such as stewards, caterers, etc.) and capacity use is generally much lower than in freight transport. Productivity performance in air transport was relatively close between countries. It was highest for Germany and The Netherlands. Only in France and Sweden, it was still almost 8 and 12 percentage points lower than in the USA respectively.

Table 2 – Relative levels of output per person employed in transport, US=100, 1992

	Water Transport	Air Transport	Rail and Road	Transportation Services	Total Transport
France	55	92	81	98	88
Germany (-West)	68	112	64	(a)	67
Netherlands	79	111	113	105	115
Sweden	102	88	93	76	97
United Kingdom	45	109	55	85	70
United States	100	100	100	100	100

(a) transportation services are included in other transport industries
Note: converted to US dollars on the basis of multilateral “Geary Khamis” – UVRs, which are derived from industry-specific bilateral UVRs.

Source: Kune, Mulder and Rabaud (1998), based on Van Ark, Mulder and Monnikhof (1999) for France, Germany and Netherlands and on O’Mahony (1998) for UK.

Table 3 presents comparative productivity levels in the trade sector. Output is defined as the gross margin, which is the difference between gross sales and purchases of goods. Labour productivity in the European countries is 10-15 percentage points below the level of the United States, but again the figures vary substantially by sub-industry. For example, in all three countries productivity in food retailing is higher than in the United States. Clearly such measures are not only indicative of the innovation process, and perhaps even not of the efficiency of the resource use in the sector. They may also represent effects of differences in market structures on productivity. For example, restrictive opening times of shops or other measures that reduce competition may positively impact productivity when measured as value added per hour worked.

Table 3 – Relative levels of gross margin per hour worked in trade, US=100, 1992

	Retail Trade			Wholesale Trade			Total
	Durables	Non-durables excl. food	Food	Durables	Non-durables excl. food	Food	
France	83	67	144	63	92	110	85
Germany (-West)	85	107	114	111	76	89	92
Netherlands	90	53	116	99	124	96	89
United States	100	100	100	100	100	100	100

Note: gross margin defined as sales minus purchases converted to US dollars on the basis of industry-specific bilateral UVRs for sales and purchases separately.

Source: Van Ark, Mulder and Monnikhof (1999).

In conclusion, the popular claims that slow productivity growth for the economy as a whole is mainly accounted for by services, that productivity levels in services are fairly similar across countries, and that the potential for productivity improvements in services is limited need to be carefully reconsidered. Indeed there are large differences between countries in terms of output and productivity performance. On the one hand, the European countries (with the exception of The Netherlands) have experienced faster productivity growth in services than the United States. On the other hand the service productivity levels in European countries are not significantly higher than in the U.S., which suggests that much of the recent growth is due to a "catch-up"-type of rapid investment. However, the productivity differentials not only represent differences in efficiency and innovative capacity, but also differences in functioning of markets in each of the countries, which in turn affects the potential for innovations in the sector that stimulate output and productivity growth.

Physical and Human Capital Input

On a pure accounting basis, output growth represents the sum of the growth of a weighted combination of factor inputs, like labour and capital, and the growth of total factor productivity, which represents the efficiency of the use of factor inputs.[6] Investment in factor inputs is a major source of output growth in services, and does not only represent labour input as is often assumed for services. For example, in market services the factor share of machinery, equipment and other tangible resources in gross domestic product is about 35-40%, which is not significantly lower than the share of capital income for the rest of the economy. Investment in tangible capital can be an important carrier of innovation and high investment levels may therefore be an indication of rapid innovation.

Table 4 - Capital Intensity in Service Sectors, 1985-96, and as a % of the U.S. (1996)

	Wholesale and Retail Trade	Transport and Communication	Finance, Insurance Real Estate & Business Services	Other Market And Non-Market Services	Total Service Sector	Total Economy
Average annual growth rate of capital stock per hour worked (1985-1996)						
France	3.7	3.4	2.6	2.9	2.9	2.9
Germany	3.2	2.4	3.2	2.2	2.4	2.9
Netherlands	1.3	1.2	(a)	0.4	0.7	1.0
UK	1.8	3.5	3.1	-3.7	2.0	1.9
USA	3.6	-0.9	3.6	-1.2	0.5	0.5
Capital stock per hour worked as % of the USA (1996)						
France	124	175	121	233	166	181
Germany	95	155	118	190	142	158
Netherlands	56	272	(a)	186	157	162
UK	89	164	136	73	135	138
USA	100	100	100	100	100	100

Note: gross capital stock is calculated on the basis of the perpetual inventory method, with common assumptions on asset lives and depreciation patterns for France, Germany, UK and USA (on average 15 year-lives for machinery and equipment and 40 year-lives for structures, 20% retirement each year around the average service life and conversion at 1985 PPPs) and for The Netherlands (14 year-lives for machinery and equipment and 39 year-lives for structures, rectangular retirement at the end of the service life and conversion at 1990 PPPs)
(a) included in other market and non-market services

Source: GGDC sectoral database, see Annex A.

Table 4 shows a comparison of the growth rates and comparative levels of the stock of capital per hour worked in service industries. It appears that capital intensity in services in

[6] See the subsection on growth accounting in section 3 for more details.

the European countries - in particular in France, Germany and The Netherlands - is considerably higher than in the U.S. The low growth rates in combination with the high level for The Netherlands in 1996 suggest that the Dutch capital intensity levels in services were already relatively high in 1985. Capital intensity in The Netherlands is especially high in transport and communication, but much lower in retail and wholesale trade.[7]

Table 5 – Skill Intensity in Service Sector, 1978/79 and 1993

		Wholesale And Retail Trade	Transport and Communi-cation	Finance, Insurance Real Estate & Business Services	Communit Social and Personal Services	Govern-ment Services	Total Service Sector	Total Economy
		Share of high skilled employees in total employment by sector						
Germany	1978	2.1	3.1	12.2	8.3	21.5	10.8	6.9
	1993	3.9	6.1	18.5	9.6	26.5	14.3	11.4
Netherlands	1979	4.0	6.5	14.2	(a)	30.9 (a)	18.9	13.5
	1993	9.1	12.5	37.2	(a)	41.2 (a)	29.7	24.4
UK	1979	2.3	3.2	16.7	6.1	14.3	8.4	6.8
	1993	4.6	5.8	27.4	11.9	24.9	15.8	13.5
USA	1979	9.1	8.5	24.7	15.4	34.4	20.6	15.8
	1993	11.0	11.7	34.5	18.7	39.7	25.5	22.1
		Share of intermediate skilled employees in total employment by sector						
Germany	1978	67.3	70.7	68.3	58.8	53.0	61.9	58.5
	1993	65.7	67.2	59.8	55.5	52.3	59.1	60.7
Netherlands	1979	33.4	27.2	41.8		32.6 (a)	34.0	31.5
	1993	49.9	41.0	45.6		40.4 (a)	43.7	43.6
UK	1979	11.0	19.8	9.5	19.4	27.7	18.0	21.8
	1993	22.9	28.3	20.1	29.7	33.1	26.9	30.9
USA	1979	12.8	13.1	14.0	9.2	13.0	12.5	11.4
	1993	17.3	21.7	19.8	13.5	19.6	18.1	17.4

Note: Higher skills are defined as “degree and above”, for The Netherlands all higher education; intermediate skills are “vocational qualifications above high school but below degree”, for The Netherlands advanced general secondary education (havo and vwo above 4 years), intermediate vocational qualifications (mbo) and most apprenticeship education

(a) “community, social and personal services” and “government services”

Source: Netherlands from CBS (1979,1993); UK, USA and Germany from O’Mahony (1999)

[7] The estimates are based on the perpetual inventory method, which implies that stock estimates are derived from cumulated investment flows, which are adjusted for investments that are scrapped after an assumed service lives. Alternatively, capital intensity estimates can be based on the service flows per hour worked (e.g., Jorgenson *et al*, 1987). Service flows are derived from the stock by weighting each asset by asset-specific user cost of capital, which is given by the real interest rate plus depreciation minus real capital gains. A comparison of the stock estimates of the growth of capital intensity from Table 4 with flow estimates from O’Mahony (1999) suggests that the latter increase at a somewhat lower rate for France and Germany, and at a somewhat higher rate for the UK and for “other market and non-market services” in the U.S. (The Netherlands is not included in O’Mahony, 1999).

Another important input in the production process is human capital. Increased skills embodied in labour are generally seen as strongly supportive of innovative activities. Table 5 compares the share of high and intermediate skills in services in Germany, The Netherlands, the UK and the USA. The "high skills"-share in the U.S. is relatively large in particular compared to Germany and the UK. In Germany the smaller high skill-share is offset by a larger "intermediate skills"-share. In The Netherlands the relatively large "high skills"-share is accompanied by the second-biggest "intermediate skills"-share among the four countries. In general "high skills"-shares are underrepresented in wholesale and retail trade and in transport and communication relative to the total economy, but this is at least partly compensated by more intermediate skills. In the other service sectors "high-" and "intermediate skills"-shares are higher than for the economy as a whole, with the exception of intermediate skills in UK services.[8]

The general message from this sub-section on investment is that the innovative capacity of services in Europe through investment in physical and human capital is strong relative to the United States. However, high levels of capital intensity in combination with lower labour productivity levels in Europe relative to the United States also suggest a lower efficiency use of tangible capital in Europe.

Intangible Capital

The most important source of intangible capital is investment in research and development (R&D). However, R&D measures for services can only be used with the greatest possible caution. The rise in R&D intensity that most OECD countries have registered over the past two decades is partly a statistical artefact as the coverage of service sectors in the R&D statistics has been expanded. Moreover the coverage of services and the minimum firm size that is surveyed differs between countries. Hence, strong conclusions on international comparison are not possible.

Young (1996) has combined various OECD databases –*e.g.* STAN, DIRDE and ANBERD–[9] to analyse R&D expenditures in service industries as a whole as well as for

[8] Alternative calculations of skill-shares can be made on the basis of the OECD/STI database on skills by industry and occupation (OECD, 1998). When rearranging shares of "high-skilled white-collar workers" to high skills, and the share of "low-skilled white-collar workers" and "high-skilled blue-collar workers" to intermediate skills, the OECD data suggest a much better skill performance for Germany and the USA than the NIESR data (see O'Mahony, 1999). However, the OECD data cannot be readily used for the purpose of this comparison, as it allocates employees to skill categories on the basis of their occupation. Hence all clerks and service workers and all shop & sales workers are allocated to the low-skilled white-collar category, which is clearly an overestimation of formal intermediate skills.

[9] See Annex B for details on OECD sources from which innovation indicators can be obtained.

specific service sectors. Table 6 presents R&D figures for total services expressed as a percentage of value added for a selection of countries. Four countries (Canada, Denmark, the United Kingdom and the United States) show a strong increase in service R&D expenditures. France and Germany show a modest increase in service R&D expenditures. The R&D trends for The Netherlands were stable for a long period but more recently these have increased as well. The service R&D intensity for Belgium and Japan showed a decline.

Table 7 confirms the view that much of the differences in growth rates of R&D intensity in services are due to differences in coverage. Countries with rapid growth in R&D intensity in services had a relatively high share of service R&D in total business R&D of around 30% in 1993. The slow growers all had a service share of less than 10% of total business R&D. Despite these concerns, Table 7 identifies R&D services and computer services as big R&D spenders. There is a much bigger variation in coverage of other R&D intensive service sectors, in particular for various types of "other business services".

Table 6 Trends in Reported R&D Expenditures in Services (% of Value Added)

	1981	1985	1991	1993
Belgium	0.42	0.33	0.21	n.a.
Canada	0.16	0.44	0.58	n.a.
Denmark	0.31	0.46	0.77	0.92
France	0.07	0.08	0.15	0.24
Germany	0.09	0.14	0.17	n.a.
Japan	0.12	0.17	0.13	0.13
Netherlands	0.17	0.17	0.17	0.23
United Kingdom	0.06	0.21	0.59	0.64
United States	0.14	n.a.	0.99	0.96

Source: Young (1996)

Table 7 Share of Manufacturing and Services in Total Business R&D, 1993, in %

	Manufac-turing	Services					
		R&D Services	Computer Services	Transport Services	Commu-nication Services	Other Services	Total
Belgium (1991)	93.1						5.8
Canada	62.3	8.8	4.9	0.3	2.8	13.8	30.6
Denmark	65.9	1.8	6.7	(a)	3.7	20.3	32.5
France	88.7		2.6	2.7		1.4	6.8
Germany (1991)	95.4	1.3		0.4		0.7	2.4
Netherlands	86.7						9.8
Sweden	92.1						4.4
UK	77.6	9.5	5.3	0.1	3.0	0.3	18.2
USA	73.6	1.8	8.5		4.6	11.2	26.1

(a) included in communication

Source: Young (1996)

Finally, Young recognises the importance of R&D expenditure on software, which has been included in the surveys for some countries, including those with the highest R&D intensity and service R&D shares in Tables 6 and 7. However, there is still not much harmonisation on coverage of expenditure on software. Software will be treated as investment rather than expenditure with the introduction of the System of National Accounts 1993.

Inter-industry Accounts

So far we have mainly focussed on measures for individual service industries in relation to the total economy. These indicators measure inputs in and outputs from the innovation process. However, as mentioned in section 2.1, the "throughput" component needs to be addressed as well. This can be done by making use of inter-industry accounts, which measure the flow of intermediate inputs or capital flows between sectors in the economy. In some countries inter-industry accounts (input-output or IO tables) are regularly produced as part of the national accounts system.[10]

Recently the OECD has published IO tables on domestic capital formation, domestic transactions of intermediate inputs, imported capital formation and imported transactions of intermediate inputs for 10 countries for a couple of benchmark years since the early 1970's (OECD, 1995). These tables are available in current prices and in constant prices. Hence these allow us to identify changes over time as well as differences between countries.

The OECD input-output tables can be used to determine both the share of total intermediate transactions in services and the share of investments from various sectors in the economy into service sectors. In Appendix C we present tables C1 that report the share of intermediate inputs in services output by originating sectors for Germany, The Netherlands, the USA, the UK and France. Tables C2 show the share of investments obtained from various sectors that are used in services. In particular, we distinguish between inputs and investment flows from low-tech, medium-tech and high-tech manufacturing[11], other non-service sectors (like agriculture, construction and public utilities) and services and indicate which part of the output or investment of these sectors is used as input in services. Within services we distinguish seven industries, namely wholesale and retail trade, hotels and restaurants, transport and storage, communication, finance and insurance, real estate and business services and community, social and personal services.

During the two decades between roughly 1970 and 1990 the share of intermediate goods from low-tech manufacturing used as input has fallen in most of the service sectors.

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[10] For example for France, Denmark and the Netherlands.

[11] High-tech, low-tech and medium-tech sectors are distinguished on the basis of the R&D intensity in the sector (see Annex C).

Only in the UK there has been a relative constant share of low-tech intermediate inputs in services during this period. At the same time the share of high-tech manufactured goods as input in services has remained more or less constant during this period. Only the communications sector in Germany and the USA that witnessed a slight increase in the share of high-tech inputs. Deliveries from service sectors to other services have increased over the period. Hence, in terms of intermediate input use, services have become more intertwined with each other than with non-service sectors.

A striking difference between The Netherlands and the other countries is the small ratio of total input to total output. Concentrating on services, we find that one reason for this is the relatively low share of intermediate deleveries within a service industry in total industry input. Hence The Netherlands have relatively low diagonal elements in the matrix of input coefficients for services. The low share of these industries in their own input implies that a relatively high share must come from deliveries by other industries or from abroad. Even when we correct for the openness of the Dutch economy and relate the intermediate deleveries to total economy-wide input corrected for foreign trade, we still find relatively low 'own' inputs for services. So Dutch services are more intertwined than elsewhere.

When the share of investments from particular sectors used as input in services is considered, a more pronounced picture emerges. For all countries under consideration we find a clear rise in the share of high-tech investment goods in the communications sector. The size of this share is also large in comparison to the share in other services. High-tech investments may make up 50% or more of total investments in communications. Only the Netherlands has a remarkably lower share of around 25%[12].

Trade, transport, financial and business services and non-commercial services have also experienced an increasing share of high-tech investments in many countries. The share of low-tech investments has fallen in some service sectors, while it remained constant in others. The share of investments from other non-service sectors to many of the services has also fallen considerably during the period 1970-1990. In some service sectors, in particular those with limited potential for rapid innovation like hotels, the share of medium-tech investments increased.

Summarising, between 1970 and 1990 the share of inputs in services has shifted largely from low-tech manufactured intermediate goods to intermediate goods from other service sectors. This indicates that service industries have become more intertwined. The

[12] On the other hand, The Netherlands have a fairly high percentage of investment goods from the medium-tech manufacturing sector as input in communications (30%), while for the other countries this is less than 10%. The major reason for this phenomenon is the fact that the electronics concern Philips is diversified in such a way that nearly all its activities are attributed to the medium-tech sector 'electrical apparatus'.

share of high-tech intermediate goods from manufacturing to services has shown no dramatic rise during this period. Low-tech manufactured investment goods as share of total investment in services has fallen during this period. At the same tine, the share of high-tech investment goods has risen in almost all service sectors, most strongly in communications. Another noticeable observation is that the share of investment goods from other non-service sectors, like construction and installation, has fallen for many service sectors.

2.3 Micro Level Indicators

Over the past two decades several firm-level surveys that allow study of innovative activities at a more disaggregated level have been conducted. During the 1980s several technology surveys were carried out to quantify the adoption of particular new technologies. Given the nature of the surveys, the focus was on frontier technologies (like robots, micro electronics or high-performing materials) and the surveys were often concentrated in manufacturing.

More encompassing innovation studies were carried out since the mid-1980s, and these increasingly included measures for firms in services as well, though to a limited extent. Since the early 1990s there have been attempts to co-ordinate the innovation surveys across the European Union. The first Community Innovation Survey (CIS-I) was carried out in 1992, but the results have not been published for the European Union as a whole. Services have only been covered for Germany, the Netherlands, Italy and Greece, and there are serious problems in comparing these measures across countries because of large non-response rates and differences in cut-off points of the minimum firm size sampled. Recently the second Community Innovation Survey (CIS-II) has been carried out for 1996, which has a more extensive coverage of services, but results are not yet available on a European-wide scale.

Below we first discuss firm-level surveys that include services for the Netherlands. Next we look at results from similar surveys for Germany, Sweden, Denmark, Italy, France and the U.K. Finally, we deal with alternative innovation measures from other micro-based surveys in The Netherlands, such as the Automation Statistics and the Production Statistics.

Firm-level innovation surveys (CIS) for The Netherlands[13]

In 1989 the Stichting voor Economisch Onderzoek (SEO) carried out an innovation survey (CIS-0) for manufacturing and services in The Netherlands in 1988, reported in Kleinknecht *et al.*, (1990). The survey mainly dealt with R&D indicators, but also included innovation measures as patents, investment in software, durable equipment and schooling.

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[13] This part of section 2.3 is based on various surveys in The Netherlands carried out within the framework of the CIS (Community Innovations Survey), which we label CIS-0, CIS-I and CIS-II.

Table 8 reproduces one of the tables from the SEO-study for 1988. It shows the percentage of firms that have an R&D department, that perform R&D outside the R&D department, that obtain their R&D from outside the firm or that perform some R&D activities in whatever form not classified elsewhere. The figures confirm the macro-figures shown above, by suggesting that service firms perform less R&D than manufacturing firms. It also shows that the percentage of service firms that do carry out R&D increases with size[14].

Table 8 - Percentage firms, by size, with different R&D activities, 1988 Netherlands

Size class: number of employees	Firm has own R&D department	Firm performs R&D in other departments	Firm has R&D outsourced	Other ways to perform R&D
Manufacturing	15.4	33.2	20.7	42.4
Services				
10-19	1.1	9.1	6.5	12.4
20-49	3.0	8.9	6.5	14.0
50-99	3.2	21.4	11.1	26.8
100-199	6.6	36.8	22.9	46.5
200-499	10.9	40.5	23.2	48.9
500 or more	22.6	50.0	36.1	64.3
Total services*	2.9	13.2	8.7	17.9
Total economy	5.9	18.1	11.6	23.9

* including public utilities and construction; see footnote 14.

Source: Kleinknecht *et al.* (1990)

As mentioned above R&D measures have only limited value in measuring innovative activities of firms in the service industry. Kleinknecht *et al.* mention some other indicators as well. The number of patent applications, the development, acquisition and user intensity of software in firms, and the schooling activities of service firms are discussed in more detail. Table 9 lists the size distribution of firms that applied for a U.S. or European patent. It is clear that the percentage of manufacturing firms applying for a patent is much higher that that of firms in service industries. This indicator of innovative activity also increases with firm size and is therefore consistent with the R&D indicator.

Another indicator, which is more suitable to grasp innovative activities in services is the development, purchase and use of software. Increasing computerisation plays a role in both manufacturing and services. One way to incorporate innovations in business activities is

[14] Note that the service sector in CIS-0 and CIS-I is not solely composed of these typical service industries, but also of firms in utilities and construction. So instead of services, it would be more appropriate to speak of non-manufacturing, excl. agriculture.

through (new) software. Table 10 gives the percentage of Dutch firms that carried out software activities in The Netherlands in 1988. We distinguish purchased software, software developed for internal use, software developed for external users and the user intensity of software, *i.e.* purchased software per employee. In comparison with the other two indicators, there is no longer a sharp distinction between innovation in manufacturing and services. In particular software-intensity is higher in services, irrespective of size, than in overall manufacturing. The software-intensity indicator suggests no relationship with firm size either.

Table 9 - Size distribution of percentage firms that applied for a patent,1988 Netherlands

Size class: number of employees	has applied for a patent	of which only European
Manufacturing	7.2	3.8
Services		
10-19	0.8	0.0
20-49	1.7	1.4
50-99	2.4	2.3
100-500	5.5	3.6
500 or more	9.3	7.9
Total services*	1.7	1.1
Total economy	3.1	1.7

* including public utilities and construction; see footnote 14.

Source: Kleinknecht *et al.* (1990)

Table 10 - Software activities by firm size, Netherlands 1988

Size class number of employees	purchased software % of firms	software development for own use % of firms	software development for external use % of firms	software-intensity: purchased software per employee guilders per employee
Manufacturing	50.9	22.8	3.5	533.1
Services				
10-19	35.7	9.2	3.7	640.3
20-49	48.2	13.1	1.6	538.8
50-99	56.1	24.5	2.0	622.4
100-500	74.0	56.2	10.7	756.8
500 or more	83.9	67.0	13.5	632.7
Total services*	45.7	16.6	3.5	644.2
Total economy	47.0	18.1	3.5	622.5

* including public utilities and construction; see footnote 14.

Source: Kleinknecht *et al.* (1990)

Table 11 presents the same set of indicators as Table 10 for a number of service industries, *viz*. trade, hotel, restaurant and repair business, transport and communication, bank and insurance business, other commercial services and non-commercial services. The Table shows substantial heterogeneity within total services. The usual distinction between more traditionally oriented service industries, like trade, hotels and repairs, and the 'modern' industries, like transport and communications has vanished. Only the category 'banks and insurance businesses' are somewhat of an outlier, as both the percentages of firms that buy software and firms that develop software for own use is higher than average in services or nation-wide. The software-intensity in the bank and insurance business is also profoundly above the levels of other services industries.

Table 11 - Software activities by service industry, Netherlands 1988

Service industry	purchased software % of firms	software development for own use % of firms	software development for external use % of firms	software-intensity: purchased software per employee guilders per employee
Trade	45.6	15.4	4.2	533.7
Hotels, repair	37.7	11.5	1.7	644.0
Transp. and comm.	39.8	16.6	2.0	359.0
Bank and insurance	62.2	28.1	4.5	2,007.5
Other commercial	54.2	30.8	7.1	652.0
Non-commercial	49.2	24.0	3.6	608.1
Total services*	45.7	16.6	3.5	644.2
Total economy	47.0	18.1	3.5	622.5

* including public utilities and construction; see footnote 14.

Source: Kleinknecht *et al.* (1990)

Finally, CIS-0 considers a number of innovation activities that firms undertake in order to improve their way of business. These indicators refer to improvements not captured by the R&D-indicator. Table 12 shows: (i) purchase of computer equipment for both office use and use in production; (ii) connection to an external computer network, (iii) hiring more skilled personnel, (iv) providing services (*e.g.* after-sales); (v) improving design. As might be expected, computerisation of production methods is much more important in manufacturing than in services. The same is true for the design of the (manufactured) products. On the other hand, firms in services pay more attention to computerisation of office equipment and in particular to connecting their systems to external computer networks.

Table 12 - Other innovation indicators by service industry (% of firms that undertake such activities), Netherlands 1988

Industry	Purchase of computer equipment for		Connection in computer network	Hire skilled personnel	Services	Design
	office	production				
Manufacturing	41.6	40.6	3.1	20.1	17.3	12.9
Services						
Trade	42.6	11.2	7.9	13.5	25.7	7.9
Hotels, repair	42.4	3.3	9.1	16.6	32.7	9.6
Transp. and comm.	37.2	6.2	8.8	10.7	20.2	1.8
Bank and insurance	63.1	5.0	19.1	21.7	26.3	3.4
Other commercial	49.0	11.7	8.1	23.0	22.7	8.3
Non-commercial	38.9	12.7	4.6	20.0	25.3	12.2
Total services*	43.6	8.2	7.3	15.1	22.2	5.9
Total economy	43.1	16.2	6.3	16.3	21.0	7.6

*including public utilities and construction; see footnote 14.

Source: Kleinknecht *et al.* (1990)

The next innovation survey for The Netherlands was carried out for 1992, and represents the Dutch contribution to CIS-I (see Brouwer *et al*., 1994 and Brouwer, 1997). This survey incorporates information from some 4,000 firms in both manufacturing and services. Table 13 is based on the CIS-I survey and is comparable to Table 8, which was based on the earlier survey for 1988. Comparison between Tables 8 and 13 suggests a fall in the 'informal' R&D activities, particularly in small firms. In other words, between 1988 and 1992 R&D outside the own R&D department has fallen considerably in all industries. The same is true for outsourced R&D. On the other hand, there was a slight increase in the number of firms with an internal R&D department.

The CIS-I survey is not designed in the same way as the CIS-0 survey of 1988 and hence not all indicators of innovative activities can be adequately compared. It is however possible to compare the R&D-intensity between the CIS-0 and CIS-I. R&D intensity is defined as the ratio of the number of R&D-labour years performed by the firm and the total number of labour years of firms. Table 14 compares 1988 and 1992 R&D intensities for various industries. It also gives information of the relative R&D intensity of the industry as a whole, as not every firm engages in R&D activities.

Table 13- Percentage firms, by size, with different R&D activities, 1992 Netherlands

Size class number of employees	Firm has own R&D department	Firm performs R&D in other departments	Firm has R&D outsourced	Other ways to perform R&D
Manufacturing	15.8	11.9	9.7	25.1
Services				
10-19	2.7	1.6	1.1	4.9
20-49	2.8	2.4	2.5	6.5
50-99	9.0	9.5	6.1	16.0
100-199	9.0	10.4	7.7	19.7
200-499	15.1	17.8	9.0	32.8
500 or more	25.4	31.6	18.1	49.1
Total services*	4.1	3.6	2.7	8.2
Total economy	6.6	5.4	4.2	1.1

* including public utilities and construction; see footnote 14.

Source: Brouwer *et al.* (1994)

Table 14 - R&D-intensities (R&D labour as percentage of total labour) by industry

Industry	R&D-intensities (R&D labour years/total labour years)			
	1988	1992	1988	1992
	% of all firms with R&D	% of all firms with R&D	% of all firms in industry	% of all firms in industry
Manufacturing	6.3	5.7	4.7	3.3
Services				
Trade	2.1	4.0	0.7	0.6
Hotels, repair	1.6	0.3	0.3	0.0
Transp. and comm.	1.1	1.5	0.6	0.5
Bank and insurance	1.0	0.6	0.6	0.2
Other commercial	1.8	3.1	0.6	1.2
Non-commercial	6.2	12.7	3.1	3.3
Total services*	1.6	2.4	0.6	0.7
Total economy	3.8	4.1	1.9	1.6

* including public utilities and construction; see footnote 14.

Source: Brouwer *et al.* (1994)

Table 14 shows that although R&D-intensity in service industries is still much lower than that for manufacturing firms, this measure of innovation activities has risen for services and has fallen for manufacturing in the period 1988-1992. Hence, service and manufacturing industries are converging in terms of R&D performance. There are still large differences within services. The R&D-intensity in the hotel and repair business has surged, as well as the

R&D-intensity for banks and insurance. The number of firms that have any R&D activities has fallen over the period 1988-1992, as was found from comparison of Tables 8 and 13 as well. Hence the increase in intensity in some service industries is due to the denominator-effect, i.e. a smaller number of firms that do R&D. This is, for example, the case in trade and transport and communication. The highest R&D intensity is found in non-commercial services. In 1992 the share of R&D labour in non-commercial services with some R&D activities is more than 12%. This industry includes scientific research institutions, medical institutions, education and other government institutions, like defence.

The same problem with CIS-I as was noted above for CIS-0 remains, namely that R&D is a poor indicator of innovation in services. Since CIS-I is of a different design than the 1988 innovation survey, there are no similar indicators as in Tables 9 to 12 for 1992. Table 15 lists the expenditures on innovations and investments in product innovations. In 1992 an average service firm spent about 30 thousand Dutch guilders on innovations and innovative investments. Table 15 shows that financial institutions spent a relatively high amount on innovations and investments. But clearly we find the highest amount of money per firm spent on innovation in manufacturing. Table 15 also shows the importance of investment as indicator of innovations in services. Service industries spend only one third of their total innovation expenses on innovations excluding investment. For manufacturing this is some 60%.

Table 15 - Expenditures on product and service innovations in 1992, Netherlands.

Service industry	Expenditures on innovation			
	excluding investments		including investment	
	mln Dfl	1000 Dfl per firm	mln Dfl	1000 Dfl per firm
Manufacturing	6,894	168	11,529	281
Services				
Trade	1,136	8	3,478	26
Hotels, repair	140	3	469	8
Transp. and comm.	477	22	1,293	59
Bank and insurance	408	37	1,101	100
Other commercial	1,082	13	2,724	33
Non-commercial	724	8	1,015	12
Total services*	3,967	10	10,080	26
Total economy	11,148	19	23,685	40

* excluding public utilities and construction; see footnote 14.

Source: based on Brouwer *et al.* (1994) and Brouwer (1997)

In 1996 the CIS-II was held, as a follow-up to CIS-I. The survey was performed by national research institutes across the European Union with co-ordination provided by Eurostat. This survey, which for The Netherlands includes a total of 47,000 firms, is conducted in each of the participating EU-countries. Table 16 shows results from the Dutch contribution to CIS-II carried out by Statistics Netherlands (CBS, 1998a). It shows that the total service sector increased R&D expenditures from 791 million Dutch guilders in 1995 to 1,209 million guilders in 1996.[15] This increase is mainly due to large firms with more than 200 employees, who almost doubled their expenditures. Nevertheless, the level of R&D expenditures in services remains considerably lower than in manufacturing.

Table 16 – Development of R&D expenditures in million guilders, of firms, by size, with R&D personnel,1995 and 1996

	1995	1996
Manufacturing	5,695	5,829
Services	791	1,209
10-49	23	189
50-199	317	297
200 or more	451	724
Total economy	6,900	7,364

Source: CBS (1998a)

Table 17 presents a number of other indicators on expenses on innovation-related activities in The Netherlands, which are derived from CIS-II. The Table lists the percentage of firms, engaging in innovations, that have spent funds on: (i) purchase of equipment; (ii) own R&D; (iii) outsourced R&D; (iv) design; (v) patents/licences; (vi) marketing and (vii) training. All these items serve to enhance innovative activities in firms, in particular in services. The final column represents the percentage of innovating firms that have spent funds on innovations in 1996.

In general terms we find that investments comprise a larger part of innovative activities in services than in manufacturing. R&D, both conducted inside the firms and outsourced, is on the other hand far less important for services. For all the other items that represent innovative activities, *viz.* design, licences, marketing and training, overall services have a higher score than manufacturing. For services industries the item 'design' represents all preliminary activities in order to realise product and process innovations. The early CIS results of The Netherlands indicate the prominent role of information and communication

[15] In contrast to CIS-I, utilities and construction were excluded from services in CIS-II.

technology (ICT) as a way of innovations in services (Tables 11 and 12). However, for other innovation measures we find substantial heterogeneity between different service industries. Investments are a relatively important means of innovation for hotels, restaurants/car trade, financial, engineering and environmental services. The share of firms in computer services and engineering that have expenses in R&D is higher than for overall manufacturing. Outsourced R&D is important in environmental services. Training is particularly important for computer services, as 80% of firms pay expenses for training activities. This is twice the amount for overall manufacturing. Consultancy also has a relatively high score in training, namely 63%. Design, licenses and marketing are considered to be important in computer services, consultancy and engineering.

Table 17 - Percentage of firms with expenses on innovative activities, Netherlands 1996

Industry	Investment	R&D own	R&D Outsourced	Design	Licences	Marketing	Training	Tot. inno
Manufacturing	61	67	30	20	10	23	42	89
Services:								
Wholesale trade	56	47	26	31	23	24	53	89
Retail trade/repair	67	22	24	16	14	20	51	84
Hotels, etc/car trade	73	29	19	21	24	18	54	91
Transport & comm.	66	45	25	32	18	21	45	88
Financial services	70	48	31	36	21	29	53	96
Computer services	67	79	24	45	45	47	80	97
Consultancy	66	59	22	43	29	26	63	92
Engineering	70	77	29	49	32	22	58	97
Other business Services	64	48	36	35	26	17	61	91
Environmental Services	70	69	57	44	14	16	51	93
Other services	70	34	13	30	19	10	41	84
Total services	64	46	26	31	23	24	53	89
Total economy	62	52	27	24	17	22	48	88

Source: CBS (1998a).

Summarising, it appears from these microdata that services caary out at least as many innovate activities as manufacturing. However, for service industries indicators of innovative activities other than R&D are of greater importance than for manufacturing. R&D plays an important role only in some typical business service industries like computer services, consultancy and engineering. They are less important in the more 'traditional' service industries like wholesale, retail and hotel business. ICT as innovation measure is *important within all service industries. We will pay more specific attention of the role of ICT in services in a later part of this section.*

Firm-level innovation surveys (CIS) for other European countries

This subsection considers the role of surveys within the framework of the Community Innovation Surveys (CIS) in other European countries, including Germany, Sweden, Denmark, Italy, France and the UK. Below we only present the contributions obtained from source in the individual countries. In due course Eurostat will collect all these results and provide more comprehensive comparisons.

In Germany the 'Zentrum für Europäischen Wirtschaftsforschung' (ZEW) has developed the Mannheim Innovationspanel. In 1995/1996 a specific survey was carried out among 2900 firms in service industries. Preissl (1997) also studied service innovations in Germany, using the Mannheim panel and a number of other data sources. In the Mannheim Innovationspanel three different fields of innovation in services are distinguished: product innovations, process innovations and organisational innovations. Table 18 presents innovation activities in German service industries during the period 1993-1995. The industrial sub-division in service industries differs somewhat from the one that was used in The Netherlands.

The highest share of product innovation was found in the ‘auxiliary to finance’-industry. However, most service firms that innovate are involved in process innovations rather than product innovation. This emphasis on investment-type innovations was also found from the Dutch surveys discussed above. Organisational innovations are less important, apart from software and consulting services.

Table 18 - Innovation activities in German service industries, as percentage of total innovation activities, 1993-95

Service industry	Percentage of		
	product innovation	process innovation	organisational innovation
Wholesale trade	36	56	8
Retail trade	42	57	1
Transport	40	52	8
Finance	33	53	14
Auxiliary to finance	61	33	6
Software	36	49	15
Consulting	34	53	16
Others	39	49	12

Source: ZEW (1996), Preissl (1997)

Other indicators for innovations in services in Germany, based on the Mannheim Innovationspanel, are the expenditures related to innovations of various kinds. The percentage of expenses on each item, which is listed in Table 19, confirms the relatively low share of R&D expenses in services observed above. Only in software services there is a substantial share of firms (43%) that have invested in R&D. One-third to half of service firms are involved in innovation activities mentioned in the last three columns of Table 19.

Table 19 - Share of firms that have invested in innovations of various kinds, Germany 1996

Service industry	Conception of new services	R&D	Tests and market introduction	Improvement of procedures	Follow-up investment	Training and qualification
Wholesale trade	35	17	27	49	43	38
Retail trade	35	6	24	53	61	31
Transport	31	5	17	50	47	25
Finance	43	7	22	62	48	44
Auxiliary to finance	37	11	18	53	44	43
Software	47	43	24	26	35	37
Consulting	38	27	23	35	39	28
Others	42	11	22	47	47	39
Total services	37	13	24	48	48	35

Source: Preissl (1997)

Licht and Moch (1999) also present innovation indicators for the service sector in Germany, using the Mannheim Innovationspanel. Table 20 shows the share of innovative firms that have stated that technology is important for their innovative activities. In particular this Table shows the importance of information and communications technology (ICT) as the basis for innovative activities in services. About 70-90% of service firms in all industries state that either software or computer hardware is important for their innovative activities.

Besides the important role of ICT, ICT-related technology, like high-speed communication networks (ISDN), is of considerable importance for innovative activities as well. This is especially true for industries in which computerisation plays a major role, such as software services and banking and insurance. Media, printing and publishing technologies are of particular interest for software services and technical consultancy. In this latter industry measurement, control and environmental technologies are also important for innovations. The same is true for the trade sector. Developments in medical and biological technologies are of little importance to innovative activities in services.[16]

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[16] CIS-II also includes important information on other innovation-related issues, such as targets, sources and restrictions of the innovative process. Such information has been published for Germany (BMBF, 1999), The Netherlands (CBS, 1998), Denmark (DTI, 1997), Italy (Evangelista and Perani, 1998), France (Ministère de l'Economie, 1999) and the UK (Craggs and Jones, 1999). We will not

Table 20 - Importance of new technologies for innovations in services, Germany 1996
(percentage of firms stating that these technologies are important for innovations)

Technology	Wholesale trade	Retail trade	Transport	Banking, insurance	Financial services	Software	Technical consultancy
Software	84	82	72	96	92	91	93
Computer hardware	83	85	84	96	96	90	95
High-speed comm. networks (ISDN)	36	42	41	61	46	75	46
Media, publ. and print. technologies	18	22	11	35	22	39	38
Transport techn., logistics	38	37	80	4	8	7	14
Measurement and control technologies	24	27	10	9	0	16	32
Medical technology	7	10	2	1	0	1	2
Biotechnology	10	6	2	1	0	1	2
Environmental technology	31	27	33	5	7	13	37
New materials	28	12	12	1	4	3	21

Source: Licht and Moch (1999).

For Sweden, Marklund (1996) provides indicators of innovation activities in service industries. Marklund focuses on series of interrelated intangible investments as quantitative indicators of innovative activities. Table 21 shows the (intangible) investments in software and ICT-systems in 1996-97 in Swedish crowns (SKr). The Table also lists the share of investments in software and ICT-systems as percentage of total (tangible and intangible) investments. The share for services lies substantially above the share for manufacturing. Business services account for more than half of total service investment in software and ICT-systems. Some 11% of overall investment in business services is spent on software and ICT.

Table 21 - Investment in software and ICT-systems in Sweden, 1996-97

	Intangible investment in software and ICT-systems in mln Skr	As percentage of all investments
Manufacturing	1,782	1.6
Trade	430	5.8
Business services	498	10.9
Total services	928	2.5
Total economy	2,797	1.8

Source: Marklund (1996)

show these results here as it is more distant from the main issue in this paper, *i.e.* the construction of a service innovation database.

The Danish CIS-II is analysed by the Danish Technology Institute (DTI, 1997). Some 80% of Danish service sector firms have implemented renewals in the period 1993-1996. Most firms engaged in product innovation (64%) and process innovation, (61%), while 45% and 55% have had innovations with regard to organisation and market behaviour respectively. Table 22 gives a review of the various innovative activities by service industry. It states the percentage of firms in services that have had renewal activities, or innovations, between 1993-1996.

Table 22 - Percentage of firms with innovations by type in Danish service industries, 1996

Service industry	Product innovation	Process innovation	Organisational innovation	Innovation in market behaviour
Publishing	89.5	94.7	57.9	47.4
Wholesale trade	62.4	57.8	43.4	52.4
Retail trade	40.4	39.7	20.7	45.6
Hotels and restaurants*	50.0	75.0	75.0	75.0
Transport & communication	54.5	47.6	45.2	54.8
Finance	92.3	85.7	50.0	57.1
Real estate	64.8	61.5	43.4	43.4
Business services	70.4	70.4	50.4	60.5
Cleaning services	66.2	61.6	50.7	64.4
Health care	43.3	35.5	33.3	33.3
Entertainment*	0.0	50.0	25.0	50.0
Total	63.5	61.5	45.1	54.8

* the survey includes only few firms within this industry, so we use 0-digit percentages here.

Source: DTI (1997)

Clearly most innovations in Danish services take place in finance, publishing and business services. Also cleaning services frequently engage in innovations, particularly those with respect to the organisation and market behaviour. Industries that report relatively few innovative activities are retail trade and health care. There is no comparison with innovations in manufacturing firms, nor is there an indicator of innovation. However there is some information on the importance of ICT in (process) innovations in Denmark. As we have argued before, the role of ICT might act as innovation indicator. Table 23 lists several ICT-applications of which the firms state that they have been used to produce innovations.

Mobile phones have greatly contributed in producing new types of services. Also the possibility of ICT-applications to exchange data in various ways, like email, EDI, and the possibilities of the Internet to provide information, have stimulated innovative activities in services. Other Internet applications, like ordering and payment, have not been used frequently as yet. In the future however firms expect a growing use of the Internet for these activities as well (DTI 1997).

Table 23 - Percentage of innovative firms in Danish service industries that use ICT fore their service innovations, 1993-1996.

ICT-activity	in use for innovations in percentage of innovative firms
Mobile phones	69.8
Electonic mail (email)	69.3
Electronic data interchange EDI	31.9
Internet homepages (one-way WWW)	41.8
Internet with possibility of ordering (two-way WWW)	18.8
Internet with possibility of payment (three-way WWW)	4.7

Source: DTI (1997)

Evangelista and Perani (1998) and Sirilli and Evangelista (1998) provide a distribution of costs spent on various innovations using a detailed classification of Italian service industries, which marks the Italian contribution to CIS-II. Table 24 presents some innovation indicators from these studies, which consist not only of activities generating technological knowledge, such as R&D, but also on the processes of technology adoption and diffusion. Innovative activities of the service industries are identified as R&D, design, acquisition of know-how, acquisition and development of new software, training activities necessary to introduce innovations, marketing and investment in equipment and machinery.

Of all innovative activities in services, investment is the most important component, representing 46% of total innovation expenditure in services. Software expenditures account for 14% of innovation expenses, which is less than the share devoted to R&D activities (24%). The other components play a minor role covering some 16% of total innovation expenses. In manufacturing firms R&D expenses play a more prominent role in innovations than in services.

Table 24 also shows that heterogeneity between the different service industries is substantial. In some industries, notably R&D services, engineering and technical consultancy, the highest innovation expenses are on R&D. Postal and telecommunication services have a higher than average share spent on R&D as well. Waste disposal, other business services and security services, on the other hand, hardly spend on R&D. Investment is by far the most important component of innovative activities, particularly in waste disposal, land transport and shipping and sea transport. In advertising acquisition and development of software is most important as innovative activity (62.5%). Remarkably, this is also the case for retail trade and repair (of motor vehicles), where almost 40% of innovation expenses is spent on software. Banking also has a fair share of innovations via software (36.5%). Little innovations through software are found in R&D services, waste disposal services and land transportation.

The other innovation components are all less important. Services industries with a high share of training activities to introduce innovations are e.g. legal accounting and cleaning. Design is particularly important in computing and software services (33%), but also in legal accounting, air travel and insurance. Acquisition of know-how is also relatively important in air travel and also in banking. Finally, marketing as an innovative activity is important for the hotel and restaurant business and for advertising and technical consultancy services in Italy.

Table 24 - Percentage of (innovation) costs and innovation intensity by industry, Italy 1996

Service industry	R&D	Design	Know-how	Software	Training	Marketing	Investment	Innovation intensity*
Services in:								
R&D	83.9	6.7	0.7	1.0	0.9	0.2	6.5	49,632
Engineering	70.6	5.5	3.0	5.8	2.5	0.3	12.3	10,003
Techn. consultancy	53.8	1.8	0.2	6.1	4.6	7.0	25.5	7,398
Comp. and software	18.3	32.9	9.1	12.8	4.5	1.8	20.6	5,201
Other fin. services	0.6	10.7	0.3	39.2	2.2	0.3	46.7	4,740
Advertising	5.4	8.2	1.9	62.5	1.7	7.0	13.3	3,577
Wholesale trade	4.5	3.7	2.1	18.4	3.3	2.3	65.8	3,026
Insurance	9.1	18.5	6.4	29.0	5.2	1.1	30.7	2,630
Waste disposal	0.0	5.8	0.0	1.5	2.2	1.4	89.0	2,576
Legal accounting	10.1	21.6	5.6	18.6	13.7	2.0	28.3	2,340
Land transportation	1.5	1.1	0.5	2.1	0.5	0.5	93.8	2,244
Other business services	0.0	5.2	4.1	15.7	0.7	1.2	73.0	1,823
Post and telecom.	25.4	0.6	1.5	5.4	0.0	4.2	63.0	1,808
Banking	3.3	10.9	8.3	36.5	5.8	1.6	33.6	1,658
Trade and repair	2.1	11.0	0.4	39.1	6.1	0.4	40.9	1,571
Air travel	1.8	21.1	8.8	27.1	3.6	0.0	37.6	1,415
Travel and transp. services	4.3	7.1	4.0	19.6	2.6	1.2	61.2	1,211
Shipping and sea transport	0.8	3.5	0.5	5.0	0.7	0.5	89.2	1,111
Hotels / restaurants	2.1	4.8	1.5	25.3	3.2	11.5	51.6	575
Retail trade	1.0	4.8	4.3	22.0	2.0	4.8	61.1	494
Cleaning	3.5	1.6	2.7	21.2	9.5	1.1	60.4	328
Security	0.3	0.0	1.2	19.9	3.9	1.0	73.8	241
Total services	23.7	8.1	3.5	14.1	2.6	1.9	46.0	2,315
Manufacturing (1992)	36.0	7.0	1.0	-	-	2.0	47.0	7,831

* innovation expenses in ECU per employee; - is not available

Source: Evangelista and Perani (1998)

Table 24 also shows the intensity of innovations by industry in Italy, expressed as the amount spent on innovative activities per employee. The Table is organised in such a way that the services are listed from high to low intensity industries. Italian service firms spent on average 2,315 Ecu per employee on innovations in 1995. The equivalent figure for the manufacturing sector (for 1992) was 7,831 Ecu per employee. Only R&D services, engineering and technical consultancy services spend a similar or higher amount on innovations than the average manufacturing sector.

The CIS-II results for France are published by the French Economics and Finance ministry (Ministère de l'Economie, des Finance et de l'Industrie, 1999). Table 25 focuses on the innovation indicators in French services in 1996, listing innovation expenses in the most important business service industries, i.e. telecommunication, computer and software services, and technical engineering. The amount of money spent on innovations in these three industries is only 5.3% of what is spent by manufacturing firms. Of these expenses most is spent on R&D internal to the firm. Alternative innovation measures, like the conception of new ideas, co-operation with other innovators and commercialisation (marketing) of new or improved products, are of specific importance in the computer service industry.

Table 25 - Percentage of expenses on innovative activities in France, 1996

Type of innovation in:	Telecom	Computer services	Technical consultancy	All three*	Manufact sector**
% of innovation expenses in:					
R&D internal	92.2	85.1	88.1	88.9	65.9
R&D external	4.8	2.3	4.5	4.0	9.8
Acquisition of equipment tied to Innovations	0.9	4.4	2.9	2.5	11.1
Acquisition of other technologies tied to product or process innovation	0.6	2.1	1.4	1.3	0.9
New ideas and other preparations for creating new or improving products	0.4	2.8	1.4	1.4	6.9
Co-operation with other firms with respect to innovation techniques	0.4	1.2	0.7	0.7	1.2
Marketing of new or improved products	0.6	2.2	0.9	1.2	4.2
Total	100.0	100.0	100.0	100.0	100.0
in billion Ffr:					
Innovation expenses	3.1	2.2	2.2	7.5	141.4
% of all expenses:					
Innovation expenses of innovating firms	2.0	2.8	3.4	2.6	6.0
Innovation expenses of all firms	1.9	1.8	2.1	1.9	4.7

* Firms with more than 10 employees
** Firms with more than 20 employees

Source: Ministère de l'Economie, des Finance et de l'Industrie (1999).

The French publication also shows the number of firms that have innovations in the services they provide, as percentage of all innovating firms. Table 26 gives an overview of these figures for the same three service industries as in Table 25. These figures show the share of innovating firms in business services in France. Unfortunately the publication does not provide information on what these services innovations consist of. In business services more than 50% of innovating firms have innovations in their services, while in manufacturing this is true for some 40% of the innovating firms.

Table 26 - Innovations by type in innovating firms with more than 20 employees, France 1996

Firms by type of innovation in:	Telecom	Computer services	Technical consultancy	All three	Manufact. sector
% of innovating firms that have					
- innovations in 1996	64	59	51	55	45
- planned innovations in 1997	54	47	45	46	35
- service innovations	61	55	48	52	41

Source: Ministère de l'Economie, des Finance et de l'Industrie (1999).

Craggs and Jones (1999) present some of initial results of the British CIS-II. Table 27 presents the proportion of innovating firms in manufacturing and services by size. Innovators are defined as those firms that have introduced any technologically new or improved product, process or service between 1994 and 1996. The results distinguish between size and industry. Small and medium sized enterprises (SME) have less than 250 employees, while large firms have more than 250 employees. Furthermore, this Table also provides the share of firms that have introduced a product, process or service that was entirely new to the market. The latter are called "novel innovators". There is a large difference between the industries. In manufacturing, innovators mainly consist of large firms. In services they are more evenly spread between SME's and large firms. The overall percentage of innovating firms is clearly lower in services. For novel innovators we find a similar picture. In this case, however, the concentration in large firms is more pronounced than in case of innovating firms.

Table 27 - Percentage of innovating and novel innovating firms in the United Kingdom, 1996

Type	Size	Manufacturing	Services	Total economy
Innovators	SME	48	54	52
	Large	83	58	74
Novel innovators	SME	10	7	8
	Large	33	23	29

Source: Craggs and Jones (1999)

Other results concern the role of innovative organisational and management activities, technological innovations and the relation between employment growth and innovations. This latter is dealt with in more detail in the next Section on the analysis using innovation data. Table 28 shows that 43% of the innovators is engaged in organisational and management changes, while only 28% of the non-innovating firms conducted such changes. Manufacturing firms engage in these changes more often than service firms. The Table shows that R&D, both internal and external to the firm, is a less important activity for innovative service firms than for innovative manufacturing firms. Technological activities are considered of more importance to innovation process than R&D. Finally, as was shown before, employment has grown stronger in services than in manufacturing. Moreover, the employment growth rate was much higher for innovators than for non-innovators. Innovation therefore stimulates employment instead of discouraging it. Table 28 the results of the British CIS-II also indicate that employment grew faster in small and medium sized firms than in large firms. This latter aspect is especially true for services.

Table 28 -The percentage of firms engaging in different innovative activities and the employment change and the relation with innovations, United Kingdom 1996

Aspect /activity	Type of firm	Manufacturing	Services	Total economy
Organisational changes*	Innovators	58	35	43
	Non-innovators	25	30	28
	All enterprises	41	32	36
R&D (internal/external)*	Innovators	42	14	25
	All enterprises	21	8	13
Other technological innovations*	Innovators	62	41	49
	All enterprises	31	22	26
Employment change**	Innovators	10	14	12
	Non-innovators	0	7	3
	All enterprises	6	10	7

* figures pertain to the percentage of firms engaged in these activities
** figures pertain to the percentage change in the number of employees between 1994-1996

Source: Craggs and Jones (1999)

Summarising, this subsection has presented several studies on innovation for European countries based on the CIS. However, since Eurostat has not brought all results together yet, the results still have a scattered character. Nevertheless we find, like for the Dutch CIS, that the usual innovation measure, R&D, is still important in business services, as consultancy, engineering and computer services. In more traditional services it is less important. Innovations in services pertain more to process innovations than product innovations. The new innovation measures introduced here grasp that idea. We find that computer, software and ICT investments are important innovation measures, particularly in services. Also investment-like expenses on marketing, training and other technological innovations besides R&D and ICT are important of represent this character of (process) innovations in service industries.

Innovation measures from other micro-based surveys
Innovation measures may also be derived from sources, which have not specifically been designed for measuring innovative activities. As the early Dutch CIS results showed a prominent role for innovation through information and communication technology (ICT), which was corroborated in the studies for other European countries, we will proceed by first discussing results of a relatively new statistical publication of Statistics Netherlands (CBS) on the degree and types of automation in Dutch (service) firms. Next we will discuss indicators from studies for The Netherlands that were obtained from the Production Statistics.

From 1983 onwards Statistics Netherlands has surveyed the degree of automation in the private sector of the Dutch economy. Among other things, the survey provides data on the development of the types of computer hardware in use, the expenses on automation of different kinds and the use of Internet. Especially the possibility of offering services via the Internet can be recognised as an innovation[17]. Table 29 reports the percentage change in the use of different types of computer hardware in various industries between 1996 and 1998. It shows a shift towards the use of PC's linked in a network and as a result an increase in the number of servers, while the role of stand-alone PC's flagged. The use of terminals, which imply a minicomputer or a mainframe, has dropped even more. The latter computer types are subdivided in those costing less than 200,000 guilders and those costing more than 200,000 guilders. We also show the number of these computer types linked in a network. The use of mainframes/minicomputers linked in such a network has risen more than the use of these types in general.

Table 29 - Average annual percentage change in the use of specific types of computers, Netherlands, 1996-1998

Industry	Stand alone PC's	Network PC's	Terminals	Servers	Minicomputers/ Mainframes		
					<200K	netw.	≥200K
Trade/hotels/repair	2.1	16.3	-9.3	10.9	4.0	8.7	-0.7
Business services	-8.6	11.1	-18.4	10.0	7.8	13.1	2.3
Other services	0.0	17. 9	-11.9	14.3	6.3	19.2	6.4
Services	-1.9	14.1	-13.1	11.2	6.4	11.7	2.3
Manufacturing	-10.9	12.0	-20.4	12.3	8.5	5.9	1.8
Total	-3.2	13.6	-14.9	11.2	6.7	10.6	2.3

Source: CBS (1998b)

[17] See also The Economist (1999a, 1999b)

The highest share in computer use is observed in business services. Roughly one third of all computer types are in use in business services, while manufacturing uses some 20%. The entire service sector uses almost 75% of all computers. The shift towards linked computers, be it PC's or mainframes, can also be interpreted as an innovation. The innovative aspect is that networks facilitate communication between different kinds of users with different kinds of data. The surge of the Internet as an instrument to offer goods and services plays a key role in these communications.

Table 30 shows the distribution of automation costs on different items by industry. The automation costs per automated firm are about the same in services as in manufacturing[18]. Only in business services automation expenses per firm are twice as high as in manufacturing. The wage costs of automation personnel in services are 40% of total automation costs in services and are 10 percentage points above the level for manufacturing. Services and manufacturing do spend about the same share on computer hardware. Services industries spend a higher share of costs on hiring external automation personnel.

Table 30 - Distribution of automation costs, Netherlands 1996

Industry	1000 Dfl.	in % of total automation costs					
	Automation costs per autom. firm	Hardware	Standard software	Custom-made software	Hiring costs automation personnel	Wage costs automat.	Other costs
Trade/hotels/repair	101	36	7	6	13	35	4
Business services	720	26	7	6	12	41	8
Other services	159	41	10	5	8	30	5
Services	302	29	7	6	12	39	7
Manufacturing	307	31	9	9	8	30	12
Total	260	30	8	7	11	36	8

Source: CBS (1998b)

Finally, we consider the number of firms that use the Internet to offer services to their customers. This particular usage can be considered a major (process) innovation[19]. Table 31 shows the percentage of automated firms that offer services via the Internet. This percentage has doubled between 1996 and 1998. Table 31 also shows that use in the service industries has risen faster than in manufacturing. The difference between the two has dropped from 2 percentage points in 1996 to less than 0.5 percentage point in 1998. Hence, services are catching up in this respect.

[18] An automated firm has computer equipment of more than 500 guilders and/or automation personnel.
[19] These firm-customer relations do not only pertain to connecting firms and consumers, but especially

We can also distinguish between Internet use as shop window, for transactions (orders/sales), for payments, for after-sales services and other use. The increase in Internet use in services is mainly as shop window and for after-sales services. For manufacturing the number of transactions via the Net has increased dramatically, but less so for services. However, service industries have taken advantage of other internet innovations, since their growth rates exceed those of manufacturing, apart from 'transactions'.

Table 31 - Average annual percentage change in the number of automated firms that use Internet as a way to offer products and services, Netherlands 1996-1998

Industry	% of automated firms that offer via Internet		average annual % growth in use of Internet as:				
	in 1996	in 1998	Shop window	Transactions	Payments	After-sales	Other
Trade/hotels/repair	7.4	16.0	61.9	18.9	21.9	49.9	47.5
Business services	11.7	22.9	49.3	52.9	70.2	42.7	35.5
Other services	7.3	19.4	63.5	82.9	84.1	57.7	78.4
Services	8.7	18.9	56.9	39.8	46.9	48.4	45.6
Manufacturing	10.7	19.3	34.4	142.0	42.0	35.3	4.7
Total	8.0	16.9	51.5	58.1	46.4	46.4	26.7

Source: CBS (1998b)

A second more specific study of Dutch service firms uses a data set of firms in business services to analyse the impact of entry and exit of firms on productivity performance (van der Wiel, 1999). This paper contains important conclusions. Firstly, there is large heterogeneity in performance within business services at the 3-digit SIC industry level (SIC definition 1974). Secondly, both the level of labour productivity and productivity growth of new firms is below that of incumbent firms. Considering the high level of competition in business services, the market share of incumbent firms decreased. Table 32, which is derived from the study by Van der Wiel, enables us to make some tentative conclusions on the innovative capacity of business services.

New firms generally have higher investment rates than incumbent firms, which suggests that they use the latest innovations incorporated in these investments. This is especially the case for computer services (SIC 843) and publicity and advertising agencies (SIC 845). This assertion is supported by results from Tables 17 and 22, which considered investment as an important aspect of innovative activity in service industries. There is,

to connecting firms with each other. See The Economist (1999a, 1999b).

however, no evidence that entering firms benefited from these innovations in terms of higher levels of labour productivity. As far as productivity growth is concerned, there is no contribution of either incumbent firms or entry and exit of firms to productivity growth in business services as a whole during 1988-1995. However, within business service industries productivity growth differs between firms. Incumbent firms all have modest productivity growth figures. On the other hand, productivity changes due to entry and exit are very volatile. Firms that stop their operations (exit) generally contribute positively to productivity growth, *i.e.* those exiting firms had a lower than average productivity level. Firms that have started operating in business services (entry) generally have a negative contribution to productivity growth. Only new accountancy and publicity and advertising agencies have a productivity level above industry average. On the other hand, firms that entered the market of economic consultancy agencies depressed productivity growth substantially.

Table 32 – Annual labour productivity growth and investment shares in business services due to firms that operate continuously between 1988-1995 and due to entry and exit of firms.

Industry	SIC '74	Labour productivity growth				Investment rate*		
		Incumb.	entry	exit	total	incumb.	entry	exit
Auditors, accountants, etc.	842	½	¼	½	1	3½	3¾	3¾
Computer services	843	-¼	-1½	¼	-1½	4½	12¾	1½
Architects, technical engineering	844	½	-1¼	¾	0	n.a.	n.a.	n.a.
Publicity and advertising agencies	845	½	½	-½	½	1¼	36½	1¼
Economic consultancy agencies	846	-½	-4½	¼	-4½	2¾	4¾	6¼
Press/news agencies other bus. serv.	847/9	¼	0	1½	1¾	n.a.	n.a.	n.a.
Total business services**	84**	0	-¼	¼	0	n.a.	n.a.	n.a.

* investment in 1987 as % of output

** in fact: business services (SIC 84) minus legal services and securities (SIC 848)

Source: van der Wiel (1999)

Another study using micro level data that can be used to capture innovation in services examines the evolution of the trade sector in The Netherlands over the period 1988-1995 using a firm-level longitudinal database (Broersma and McGuckin, 1999). The principal focus of the study is the impact of computer technology on productivity performance. Computer technology can be regarded as a proxy measure of innovations in the Dutch trade sector. Table 33 presents the percentage of firms in various trade industries at a 3-digit SIC level (SIC definition 1993) that have had positive investments in computer hardware over the period 1988-1995. Notice that both this and the previous study show that the use of micro level data enables us to give detailed information at a very disaggregated SIC level.

Table 33 – Percentage of firms with positive investment in computers, based on a balanced panel of 2,687 firms in the trade sector, 1988-1995.

Industry	SIC '93	1988	1992	1995
Wholesale	51	51.0	60.3	64.6
of agricultural products and live stock	512	40.9	51.4	56.5
food and stimulants	513	46.8	55.6	59.0
other consumer products	514	57.1	66.8	68.5
machines, equipment and accessories	515	51.1	62.4	64.0
other specialised wholesale	516	51.0	58.9	71.1
Retail	52	26.9	36.8	47.5
of non specialised products	521	24.6	27.9	44.1
food and stimulants	522	6.7	16.9	22.4
pharmaceutical and medical products	523	20.8	45.5	61.9
other specialised products	524	30.9	44.7	51.0
products not in a shop (market/mail-order)	526	46.2	43.8	69.2
Total trade industry	5	42.2	52.1	58.4

Source: based on Broersma and McGuckin (1999)

Table 33 confirms the increased importance of computer technology in the Dutch trade sector, which implies the importance of (process) innovations in this sector. There are more wholesale firms with positive computer investments than in the retail sector. There is also substantial heterogeneity within the wholesale and retail sector. This is especially the case in retailing. For specialised retail sales of foods and stimulants (SIC 522), of which, *e.g.* supermarkets, there are relatively few firms with positive computer investment, less than 25% in 1995. On the other hand, almost 70% of the mail-order firms (SIC 526), another class in retail trade, had positive computer investments in 1995. Such heterogeneity comes about when disaggregated data are used.

Summary and conclusions on micro-data

Summarising, this section has reviewed a number of indicators for innovative activities in services, based on micro data. Usually these data follow from extensive surveys designed to identify those indicators. We find that R&D spending, the measure frequently used for innovations in manufacturing, appears less important for measuring innovations in service industries. The share of service firms that invest in R&D is lower than in manufacturing. Various studies on innovations in services reveal that investments generally act as an important carrier of innovations in services, originating from industries that have produced those investment goods. Especially investment in computers and/or software or other ICT-activities are important indicators. Training activities necessary to introduce innovations and acquisition of know-how are useful indicators of innovative activities in service industries as *well. In the next section we will pay more specific attention to this role of investment as carrier of innovation.*

The conclusion of this section on micro-surveys is that these add important information on innovative activities to the macro-data obtained in section 2.2. To some extent the data are more focussed on innovative activities as such. However, the surveys only slowly move away from the industrial preoccupation with R&D and patent statistics, which are inadeuate for studying the service sector. Other innovation indicators are still difficult to compare over time and between countries. Some progress is made with the latest Community Innovation Survey, but still it is questionable whether questions on the amount of funding spent on particular innovative activities capture the innovative behaviour of services in a comprehensive way.

3. ANALYTICAL STRUCTURES

The information presented in section 2 is useful as a starting point for the construction of a database on service innovation. However, to use the database effectively for the analysis of innovative activity in services, an analytical structure is needed as well. Den Hertog *et al.* (1997) present a structure to order all kinds of available information, which is a useful point of departure (see section 2.1). This section introduces a couple of analytical structures to build upon this ordering structure. Two approaches, growth accounting and input-output analysis, can be used to analyse data at the macro-level. Two other approaches, regression analysis and LISREL-techniques are introduced to analyse micro data.[20]

3.1 Macro Level Structures

Growth accounting

Growth accounting is one of the most frequently used tools to disentangle the sources of economic growth. It clearly distinguishes between the contribution of accumulated resources, such as physical and human capital, and productivity, which is the efficiency by which these resources are used[21]. The growth accounting tradition stems from the work of Tinbergen (1942), Abramovitz (1956) and Solow (1957), who defined output as a function of labour and capital. The approach identifies a “residual” which is the difference in the growth of output

[20] Other examples of analytical structures not explicitly addressed in this report are clustering techniques, see *e.g.* van der Gaag (1995), Roelandt *et al.* (1997) and Roelandt *et al.* (1999).

and the contribution of the inputs, weighted at their respective factor shares in value added. On the assumption of constant returns to scale, the factor shares represent the marginal productivities of labour and capital. The residual has been named “total factor productivity” (or the “Solow residual”). In an international comparative framework growth accounting has been extensively applied by Denison (1967), Maddison (1991, 1996) and Jorgenson (1995).

There are two major issues that need to be considered before one can apply growth accounting techniques to the analysis of innovation in services. Firstly, a sectoral disaggregation of growth accounting measures is needed. It requires sector-specific production functions with marginal productivity of labour and capital and assumptions concerning the elasticity of substitution by sector. The total factor productivity growth rates from Table 34 reflect the difference between the growth of labour productivity (see Table 1) and the growth of physical capital intensity (see Table 4) with the latter being weighted at the capital share in value added.

Table 34 – Total Factor Productivity Growth in Service Sectors, 1973-85 and 1985-96

		Wholesale and Retail Trade	Transport and Communi--cation	Finance, Insurance Real Estate & Business Services	Other Market And Non-Market Services	Total Service Sector	Total Economy
Average annual growth rate of total factor productivity							
France	1973-85	0.6	2.5	-1.7	1.5	1.0	1.9
	1985-96	-0.3	2.9	-1.6	0.2	0.2	0.9
Germany	1973-85	1.3	3.3	-0.4	0.7	2.2	1.6
	1985-96	1.4	3.1	0.1	2.9	1.6	1.4
Netherlands	1973-85	2.0	2.3	(a)	0.7	1.3	1.6
	1985-96	0.6	2.5	(a)	0.2	0.6	1.0
UK	1973-85	-0.1	1.9	-2.5	0.2	0.4	1.4
	1985-96	2.1	3.7	-2.0	-0.3	1.1	1.7
USA	1973-85	1.3	1.4	-1.1	0.7	0.6	0.6
	1985-96	1.1	2.1	-1.2	1.5	0.5	0.8

Note: total factor productivity is calculated as the difference between labour productivity growth and the contribution of physical capital intensity weighted at factor share of capital in value added. The capital weights for France, Germany, the UK and the USA are constant for 1975 (see van Ark, 1996b). The capital weights for The Netherlands change annually on the basis of the average weight of the current and previous year (see van Ark and de Haan, 1998)
(a) included in other market and non-market services

Source: GGDC sectoral database, see Annex A.

[21] Given the fact that investments are considered to be a major part of innovation expenses (see e.g. Table 22), we assume that in growth accounting studies capital accumulation (investments) and innovation are independent variables.

The estimates in Table 34 show a slowdown in TFP growth for all services since 1985, with the exception of the UK. TFP growth during the period 1985-1996 is lowest for services in France (0.2% per year) and highest for Germany (1.6% per year). The UK takes an intermediate position with a TFP growth rate in services of 1.1% per year during the period 1985-1996. In The Netherlands and the United States TFP growth has been about 0.6% per year since 1985. In all cases except Germany, TFP growth in services is lower than that for the economy as a whole. Table 34 consistently shows negative TFP growth rates for the financial sector. As indicated in section 2.2, this sector is strongly affected by measurement problems.[22]

A second issue in relation to the use of growth accounting for studies of innovation in services concerns the interpretation of the residual. Clearly it is not justified to equal TFP growth with technological change or innovation as is often done in the literature. Among other things, the residual is related to the market structure, which differs between sectors, between countries and varies over time. Economies of scale can arise from imperfect competition, which need to be separated from “real” efficiency gains (see, for example, Oliveira Martins, Scarpetta and Pilat, 1996). Furthermore, investment in human capital, in intangible capital (such as R&D) and product innovation can generate spillovers which are not or only partly captured by the residual as obtained in traditional growth accounting.[23]

Various techniques can be applied to tackle these more complex issues in growth accounting, including regression techniques and the use of R&D embodied investment flows in an input-output framework. The latter approach is discussed in detail in the next section.

Input-output analysis

Innovation activities in services can be analysed further by exploiting the input-output data from the inter-industry accounts presented in section 2.2. One possibility is to construct technology flows from the input-output transaction matrices and capital flow matrices. The intermediate deliveries and capital flows between industries in those tables are then seen as carriers of embodied technology across industries and countries. Intermediate goods or

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[22] Even though TFP estimates are strongly dependent on the production functions that are used (e.g. changing or constant factor weights, assumptions concerning elasticities) and the input variables that are included (physical capital, human capital and the degree of disaggregation of the inputs), similar studies on international comparisons of sectoral TFP growth rates by Sakurai, Ioannidis and Papaconstantinou (1996) and O’Mahony (1999) confirm the general trends outlined here. See also CPB (1998) for TFP estimates for the Netherlands. More detailed estimates from Sakurai, Ioannidis and Papaconstantinou (1996) suggest, however, a better TFP performance of industries classified to the ICT cluster, including computer and communication services.

[23] Recent innovations in endogenous growth theory emphasize the importance of such spillovers, e.g., Lucas (1988), Romer (1990), Barro and Sala-i-Martin (1995), and Aghion and Howitt (1998)

investment goods, sold by one industry to another industry, incorporate the innovations of the industry of origin. These innovations are used in the industry of destination.

There are different ways to incorporate innovations. First, Papaconstantinou, Sakurai and Wyckoff (1996) estimated technology flows by using enterprise R&D expenditure data in combination with input-output and capital investment flow data for a number of OECD countries. This latter study stresses the importance of inter-industry channels through which technology diffusion takes place. A distinction is made between equipment-embodied technology generated by the industry itself and that acquired through inputs and investment goods from other industries. Acquired technology is separated further into the portion that was obtained from domestic suppliers and that from foreign suppliers.

This analysis rests on two assumptions. Firstly, R&D expenditures are used as a proxy for technology. Secondly, inter-industry transactions are assumed to be the ‘carriers’ of technology across industries and countries. Industries purchase intermediate and investment goods from other industries. These intermediate and investment goods embody the technology (R&D expenditure) of the industries where they originate. Thus technology is assumed to flow from one industry to another when the industry where R&D originates sells products, which embody R&D, to other industries to be used as inputs in their production process. Hence, technology embodied in the output of a certain industry is the sum of its own R&D expenditures and that which is embodied in purchases from other industries, both intermediate and investment goods and both domestically and from abroad. Innovations are measured by the intensity of this embodied technology.

This OECD-study has some important results relating to services, which are summarised in Table 35:[24]

1) Innovations are mainly developed in a cluster of high technology manufacturing industries.
2) Those high-tech products are delivered mainly to industries in the service sector.
3) The use of technology in many of those service sectors is higher than their weight in the total economy.
4) The part of technology in output that is acquired from abroad has increased over time
5) The share of foreign embodied technology is more than 50% of total acquired technology in small countries. In large economies this share is much smaller.
6) About half of the embodied technology is incorporated in capital investments.

[24] The OECD study does not focus specifically on services, but whenever this was possible the role of services is emphasized.

Table 35 - Technology by source, performance and use over time in some OECD countries

	USA	Germany	France	UK[1]	Netherlands
In %					
Share of R&D acquired[*] outside firm as **%** total R&D performed					
1970's	35	43	42	28	40
1990's	39	43	42	46	47
Share of technology in economy via					
- investments[†] 1970's	36	32	35	30	30
1990's	41	35	33	33	35
- imports[‡] 1970's	4	19	24	30	60
1990's	12	28	41	55	70
Share of technology in services via					
- imported investments 1970's	2	9	10	10	26
1990's	5	15	25	27	38
Technology acquired by user sector					
- high-tech manufacturing	15	20	22	16	n.a.
- medium-tech manufacturing	10	21	14	10	n.a.
- low-tech manufacturing	5	6	6	6	n.a.
- services	65	50	51	64	n.a.
- other sectors	5	3	7	4	n.a.
Share of acquired technology from					
- ICT	49	35	44	46	48
- new materials	26	35	29	23	25
Top 3 technology performers 1	aerosp.	electr mach.	comm. equip.	comm. equip.	chem.
2	comm. equip	chem	aerosp.	pharmac.	electr. mach.
3	chem.	motor veh.	motor veh.	aerosp.	comm. equip.
Top 3 technology users 1	soc./pers. services	motor veh.	aerosp.	soc./pers. serv.	electr. mach.
2	trade	bus. serv.	transp.	aerosp.	chem.
3	bus. serv.	transp.	constr.	bus. serv.	soc./pers. serv.
Top 3 investment-based technology 1	fin.	comm.	fin.	fin.	comm.
2	electr./gas /water	transp.	comm.	comm.	transp.
3	comm.	fin.	transp.	bus. serv.	trade

Note: aerosp.= aerospace; comm.equip.= communications equipment; chem.= chemicals; electr.mach.= electrical machinery; motor veh.= motor vehicles; pharmac.= pharmaceuticals; soc/pers serv.= social and personal services; trade= wholesale and retail trade; bus.serv.= real estate and business services; transp.= transport and storage; constr.= construction; fin.= finance and insurance; electr/gas/water = electricity, gas and water; comm.= communication.

* acquired technology refers to technology via purchases of intermediate and investment goods both domestic and abroad; the complement is technology performed within the industry

† the complement of acquired technology through investment is acquired technology through intermediate goods

‡ this concerns both imported investment goods and imported intermediate goods

[1] UK figures pertaining to 1970's are in fact early 1980's

Source: derived from Papaconstantinou *et al.* (1996)

7) The service industries that are most dependent on innovations through capital investment are finance and insurance, communication and social and personal services (non-commercial services).
8) The information and communication technology (ICT) cluster is the most important source of acquiring technology in many countries.

Another line of research aims to construct technology flow matrices on the basis of patents as 'carriers' of underlying technology.[25] The first major issue is to assign patents to industries, using available patent data by the technology field they are registered in. This is done by the so-called Yale Technology Concordance (YTC) method. This method is subsequently used to predict in which industry patents are likely to emerge, to link productivity growth to patent flows, and to link patent flows to R&D purchases. However, this method requires detailed patent data that need to be linked to specific industries.[26] It is possible to use the YTC method to determine the use of patented manufacturing innovations in the service sector, but innovative capacity of the service sectors is difficult to grasp with this method since service industries are less inclined to patent their innovations than manufacturing industries.

A third way of linking innovation data to input-output tables, is to use innovation counts from micro-surveys of innovative activities in an input-output framework. Innovations can be represented by R&D expenditures, by patent counts and by the outcome of innovation surveys, like for example the CIS-I and CIS-II. DeBresson (1996) and DeBresson and Hu (1999) show how to link these innovation surveys to input-output tables and obtain measures for innovative activities of suppliers and users of innovations. There are two crucial prerequisites that have to be fulfilled in order to apply this method. Firstly, the innovation survey needs to provide very disaggregated information, preferably at a 3-digit or lower level. Secondly, the survey should supply information about the recipient market, *i.e.* which industry uses the innovative output. Under these conditions innovative interaction matrices can be *compiled* from the surveys. If this information cannot be supplied by the survey, a second-best option is to *estimate* the interaction matrices. This estimation brings about a number of new problems. The main problem is that only for large countries the estimated matrices appear to be reliable. DeBresson and Hu (1999) advise against application of the estimation method in case of medium-sized and small counties. In addition to these prerequisites, this method involves two conceptual problems as well. The first is that the supplier of a product is the only one to indicate if it is an innovation, instead of the user of the

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[25] See Griliches (1990) for an international review and van der Gaag (1995) and Verspagen (1997) for The Netherlands on the use of patents as carriers of technology.
[26] See *e.g.* the special issues of *Economic Systems Research*, volume 9, numbers 1 and 2, 1997.

product. The second is that the entire recipient market is made up of only the main user of the innovation. This disregards the multi-purpose character of many innovations. A more in-depth discussion of this method by DeBresson is beyond the scope of this paper.

As indicated in the previous sub-section, the combination of input-output analysis and growth accounting may be an important way forward to quantify innovation in services. Both the micro- and the macro-data suggest that investment in process innovation through purchases of intermediate inputs and investment goods is a major factor in the innovation process. In particular the purchases of ICT hardware and software appear to be of great importance. Sakurai, Ioannidis and Papaconstantinou (1997) apply such an input-output based growth accounting framework to estimate the impact of own R&D and of R&D embodied in investment on total factor productivity performance in 10 OECD countries. The embodied R&D variables were developed on the basis of Papaconstantinou, Sakurai and Wyckoff (1996). TFP growth was estimated on the basis of the R&D intensity of the industry itself as well as the intensity of embodied R&D derived from intermediate inputs and acquired investment goods.

Table 36 - Coefficients of Embodied R&D on TFP growth in Services for 10 OECD countries on the basis of unweighted OLS regressions

	Regression 1	Regression 2	Regression 3
ICT-using Services (Transport, Communication, Finance and Insurance, Real Estate and Business Services)	Embodied R&D 1970s: ++ 1980s: ++	Domestic Embodied R&D 1970s: 0 1980s: + Foreign Embodied R&D 1970s: ++ 1980s: ++	Capital embodied R&D 1970s: ++ 1980s: ++ Intermediate embodied R&D 1970s: 0 1980s: 0
Other Services (Trade, Hotels and Restaurants, Community, Social and Personal Services)	Embodied R&D 1970s: 0 1980s: 0	Domestic Embodied R&D 1970s: 0 1980s: 0 Foreign Embodied R&D 1970s: 0 1980s: 0	Capital embodied R&D 1970s: 0 1980s: + Intermediate embodied R&D 1970s: 0 1980s: --

++ = positive strong significant (t>1.96); + = positive weak significant (t>1.44); 0 = no relation; - = negative weak significant; -- = negative strong significant
Note: All regressions include country-specific dummies for each period. In addition to measuring the impact of embodied R&D variables in every regression, regression 2 separates embodied R&D by source of origin (domestic or imported products) and regression 3 distinguishes it by types of products (intermediate and investment goods).

Source: Sakurai, Ioannidis and Papaconstantinou (1997), Table 6

Table 36 shows that embodied R&D has a significant positive impact on TFP growth in the service sectors that heavily use computers and software. The impact of foreign R&D appeared to be stronger than that of domestic R&D, and investment goods had a bigger impact of TFP growth than intermediate goods. Hence, this study offers a positive viewpoint on the Solow “productivity paradox” by suggesting that there is a great potential for productivity growth through large inter-industry flows of new technologies. However, measurement problems and the impact of differences in market structure and the degree of product liberalisation between sectors need to be considered in the light of estimating the innovative capacities of the service sector.

In conclusion, the combination of growth accounting and input-output analysis using intermediate output and capital flow matrices is a powerful instrument to quantify the throughput effects of innovative activity, provided we assume that a large element of innovative activity is of an “embodied” nature.

3.2 Micro level structures

This section is about the possible relationships between innovations and other indicators of economic performance, such as production, productivity and employment, using micro-data from surveys as described in section 2.3. One way to derive and quantify these relationships is by means of standard regression analysis. Here, indicators of innovative activity are used to explain economic performance. However, there is another approach that takes into account that innovations or innovative activities are hard to measure. The LISREL-approach enables a relationship between unobservable (or latent) constructions, like innovations, and other latent constructions. The choice of one latent construction explains the other and implies an important role for theoretical testing and hypothesising. Hence, it helps in specifying relations between latent constructs and it may contribute to the formulation of new theories on innovations. Below we will discuss both regression analysis and LISREL in more detail.

Regression analysis

In this section some results from regression analysis are presented with respect to innovations, as to provide an indication of the possibilities this method has for analysing the micro data. The discussion of regression analysis will not go into the technical specifics of (panel)data properties or specification and estimation techniques.

Kleinknecht *et al*. (1990) study the relation between R&D-intensity and certain policy measures undertaken by the government in The Netherlands, using data from CIS-0. They find that certain government actions had a positive effect on R&D intensity of firms over the period 1983-1988, such as the INSTIR, PBTS and TOK[27]. They also found that firms with a high R&D intensity in 1983 had a less R&D intensive performance in 1988. 'Modern' industries (computers, motor vehicles and aerospace) have a higher R&D intensity.

Table 37 - Explanatory variables for annual growth in number of employees, Netherlands.

Variable	All firms	R&D firms
(Log) employees in 1983	--	--
Growth of sales (industry level) 1983-1988	++	0
R&D intensity 1983	+	0
Product related R&D	0	++
Process related R&D	0	0
Annual growth in R&D intensity	+	0
Positive development in turnover 1982-83	++	++
Positive turnover expectation 1983	+	++
Co-operation in R&D 1988	0	0
Export intensity (export share in turnover more than 25%)	0	0
Realised product innovation (new to industry in 1983)	0	0
Realised process innovation (new to industry in 1983)	0	0
Realised combination of product and process innovation	0	0
Realised or prepared product innovation (new to firm in 1983)	0	0
Realised or prepared process innovation (new to firm in 1983)	0	0
Realised or prepared comb. of prod. or proc. inno. (new to firm in 1983)	0	0
Patents granted in 1983	0	0
Improvements in ICT	++	++
Improvements in bio technology	0	0
Improvements in new materials	0	0
Motivation for innovation in 1983: more different products	0	0
Motivation for innovation in 1983: replacement of products	0	0
Motivation for innovation in 1983: new technical possibilities	0	0
Motivation for innovation in 1983: new markets	0	0
Motivation for innovation in 1983: flexibility	0	0
Schooling intensity 1988 (min 10% employees with adequate schooling)	++	0
Restriction 1983: insufficiently qualified personnel in 1983	0	+
Restriction 1988: insufficiently qualified personnel in 1988	0	0
Restriction 1983: insufficient financial means in 1983	--	--
Restriction 1988: insufficient financial means in 1988	--	--
use of at least one policy measure to stimulate R&D	++	++

++ = positive strong significant (t>1.96); + = positive weak significant (t>1.44); 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Kleinknecht *et al.* (1990)

[27] INSTIR is a subsidy on R&D employment; PBTS (Programmatische Bedrijfsgerichte Technologiestimulering) is a subsidy for various areas of technology; TOK (Technisch Ontwikkelingskrediet) is a credit facility for technological developments.

Kleinknecht *et al*. (1990) also relate (technical) innovation and employment growth during the 1983-1988 period, using CIS-0. They distinguish between analysis of all firms observed in 1983 and 1988 and firms that had positive R&D expenses. In both cases they found that ICT-related innovations, sales growth, and a positive expectation about sales led to an increase in the number of employees. Policy measures to stimulate R&D also had a positive effect on employment. There was a negative effect of the employment level in 1983 (which is included to adjust for regression to the mean) and of firms experiencing financial restrictions in both 1983 and 1988 (see Table 37).

Table 37 shows that there were differences in employment change between the two groups of firms for the following variables. The production growth in the industry in which the firms operates, and the level of schooling of the employees is only of (positive) influence for employment in the total panel of firms. For firms with R&D expenses, they find a positive relation between product-related R&D and employment, but not between process-related R&D and employment. The authors also find no effect of patenting or other innovation-related activities (apart from ICT) on employment[28].

In Brouwer *et al.* (1994) a regression analysis was performed to determine the variables that affect the R&D intensities of firms over the period 1988-1992 in The Netherlands. Table 38 gives a summary of the estimation results. The R&D intensity that firms had at the beginning of the period appears very important, both for manufacturing and for service firms. Firms with a high R&D intensity in 1988 will also have a high intensity in 1992.

Since a distinction is possible between manufacturing and services, we will focus on the role of services in determining the size of R&D activities. For service firms the results suggest a lower level of R&D intensity. This corroborates the premise made earlier that R&D is not typical for firms in services. However, if a service firm has an internal R&D department, there is a positive effect on R&D intensity. The influence of various subsidy schemes to stimulate R&D is not unambiguous. The INSTIR subsidy seems to have stimulated R&D, whereas the PBTS-subsidy has no effect (see footnote 27). Another interesting phenomenon is that service firms explain a large part of the volatility (variance) of R&D intensity.

[28] See also Brouwer (1997), Chapter 4.

Table 38 - Variables explaining the R&D intensity of firms

Variable	R&D firms
Explaining the mean of the R&D intensity:	
R&D intensity in 1988 (manufacturing)	++
R&D intensity in 1988 (services)	++
Average R&D intensity in industry	++
Change in sales (industry level) 1990-92	++
Change in sales in main activity industry (manufacturing only) 1990-92	++
Firm has internal R&D department and is in manufacturing	++
Firm has internal R&D department and is in services	++
Firm is in services	--
Firm is in manufacturing and receives R&D subsidy (INSTIR)	++
Firm engaged in PBTS subsidy in 1991 or 1992 (not in 1988)	0
Firm participated in EU R&D program in 1991 or 1992	+
Firm concentrated R&D on new materials	++
Firm concentrated R&D on environmental technology	++
Explaining the variance of the R&D intensity	
Manufacturing employees (log)	0
Service employees (log)	-
Firms is in services (not manufacturing)	++

++ = positive strong significant; + = positive weak significant; 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Brouwer *et al.* (1994)

Brouwer (1997) presents a comprehensive review of analysis with Dutch innovation data. Here, we only consider the factors that can explain certain measures of innovation and distinguish between expenditures on product and service innovations and the sale of products ‘new to the firm’ and ‘new to the industry’, both from the Dutch CIS-I.

Table 39 gives the factors that explain the firms (log of) expenditure of product and service innovation, both excluding and including investments in fixed assets[29]. These factors are reasonable predictors of the firms’ innovation expenditure. R&D spending is a good explanatory variable for innovation expenditures, as is the size of the firm. The fact whether investment in fixed assets is included or not does not appear to affect the magnitude of these two effects.

[29] See also Table 15.

Table 39 - Variables explaining innovation outlays, both with and without investment, Netherlands 1992.

Variable	excluding investment	including investment
log of product-related R&D expenses (incl. outsourced)	++	++
firm size (log employees)	++	++
R&D is permanent activity (not occasional)	++	0
firm acquired external technological knowledge	++	0
firm is in chemical industry	++	0
firm is in construction or installation industry	--	

++ = positive strong significant; + = positive weak significant; 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Brouwer (1997)

Another interesting result following from the analysis with CIS-I data are the explanatory variables for the sale of products 'new to the firm' and the sales of products 'new to the industry' to which the firms belongs. These two items can be considered as a measure of innovation. High costs and uncertain revenues which accompany such innovations (the introduction of a new product) imply that the firm has to overcome a certain (sales) threshold when the decision to introduce this new product is taken. This threshold is overcome when revenues exceed fixed costs.

The analysis will determine, as a first step, the factors behind this threshold and, secondly, the factors behind the sales per employee of such a new product. Table 40 shows whether the variables impede or promote innovations. A positive value in the threshold means that the corresponding variable is positively correlated to the threshold, *i.e.*, increases the threshold. A negative value means a lower threshold. The estimation procedure is set up in such a way that when the variable appears in both threshold and sales equation and the coefficient value is larger in sales than in the threshold, the variable increases the probability that a firm innovates. The same is true for a negative value that is smaller in the threshold equation. Only the dummy variables 'firm belongs to high technological opportunity sector' and 'firm belongs to service sector' appear in both equations.

We can derive the following inferences from Table 40. First, the sales threshold is not influenced by the average length of the life cycle of the product. Second, fixed costs based on R&D have no apparent effect on the threshold. R&D intensity on the other hand does have a positive effect on sales of new products per employee. Also R&D collaboration reduces the threshold considerably. Sales growth has a small positive effect on new product sales. The location of the firms has no effect on the threshold. In industries dominated by small firms (*i.e.* high competition) the sales threshold is smaller. Another point that has policy relevance is that Innovation Centres, which can consult and help firms that want to innovate, have no apparent influence on lowering the threshold. The fact whether a firm belongs to a high technological opportunity sector has no significant effects on innovation.[30] The results suggest that service firms do have significantly fewer sales of new products, hence lower innovations. The results for the threshold are mixed: service firms have a lower probability of sales of products new to the firm, but higher probability of sales of a product new to the industry. Finally, sales of products new to the firm are positively related to firm size, while there does not seem to be a relation with respect to sale of products new to the industry.

Table 40 - Variables explaining the threshold to take in order to introduce a new product and (if the threshold is taken) explains the sales per employee of this new product, Netherlands 1992.

Variable	Products ‘new to the firm’	Products ‘new to the industry’
Threshold		
average sector life cycle length	0	0
fixed costs (median of R&D man years by industry)	0	0
competition (presence of small businesses*)	--	0
firm consulted an Innovation Centre	0	0
firm engaged in R&D collaboration	-	--
firm acquired external technological knowledge	0	0
firm is located in central region	0	0
firm belongs to high technological opportunity sector	0	0
firm belongs to service sector	++	-
firm is strongly dependent on mother company	0	++
Sales per employee (log)		
size (log of employees)	+	0
product R&D intensity**	++	++
sales growth 1990-1992	++	++
export share in sales	++	0
firm belongs to high technological opportunity sector	--	0
firm belongs to service sector	0	--

* fraction of firms with less than 50 employees in the firm’s sector of principal activity.
** product related R&D labour years as percentage of the firms total employment
++ = positive strong significant; + = positive weak significant; 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Brouwer (1997)

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[30] High technological opportunity sectors consist of chemical, pharmaceutical, electro-technical and electronics industry, transportation, mechanical engineering and instrument and optical industries. These sectors coincide with what Pavitt (1984) calls science based, scale intensive and specialized suppliers industries.

Licht and Moch (1999) apply a regression analysis to investigate relations between innovations and labour productivity for German service firms using two different data sources. Firstly, they relate labour productivity to several measures of innovation from the Mannheim Innovationspanel. Secondly, they use data from the German Information Technology Survey to link labour productivity to more specific ICT-related investments. Without the intention of being complete, we merely replicate their main results in the same way as was done so far. Table 41 shows explanatory variables for labour productivity for all firms and firms with positive innovation expenditures. Labour productivity is positively influenced by both investments (excluding ICT) and ICT-investments. Educational expenses influence labour productivity in firms irrespective of their innovation expenses, while the share of R&D employment only affect productivity in firms with positive innovation expenses. There is no strong effect of the size of the firm in explaining productivity.

Table 41 - Explanatory variables for labour productivity in services, Germany, 1996

Variable	all firms	Firms with positive innovation expenses
all in logs		
Investment, less ICT investments	++	++
Investment in ICT	++	++
Share of R&D employment	0	++
Education expenses	++	0
Number of employees	-	0

++ = positive strong significant; + = positive weak significant; 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Licht and Moch (1999)

Table 42 shows the relation between investment in specific ICT-systems and labour productivity. These results suggest a strong positive relationship between the number of PC's and MAC's and labour productivity. Capital intensity and other type of computers or operating systems hardly affect productivity in services.

Table 42 - Explanatory variables for labour productivity in services, Germany,1996

Variable	Log labour productivity
all in logs	
capital-labour ratio	0
material	0
mainframe terminals	0
midrange terminals	+
UNIX workstations	0
PC's or MAC's	++

++ = positive strong significant; + = positive weak significant; 0 = no relation; - = negative weak significant; -- = negative strong significant

Source: Licht and Moch (1999)

Evangelista and Perani (1998) study the influence of innovations on service employment. Instead of regression, they relate various innovative activities (see also Table 24) to various employment measures by calculating correlation coefficients. Overall employment is negatively related with software expenditures. All other measures hardly correlate with employment. Next they distinguish employment by skill level. High-skilled employment is positively related with innovation expenditure, R&D and design expenditures and negatively with software expenditures. Medium-skilled employment is only weakly, but positively related with investments. Low-skilled labour relates strongly to investment, but hardly to other innovative activities. The fact whether a firm is process or product oriented does not seem to have a relation with the employment of the firm. See Table 43.

Table 43 - Correlation between employment and several indicators of innovative activity in services, Italy 1993-1995

	overall employment	high-skilled employment	medium-skilled employment	low-skilled employment
Innovation expenses	0	++	0	+
R&D and design expenses	0	++	0	+
Software expenses	---	---	0	0
Other disembodies expenses[a]	0	0	0	0
Investment expenses	0	0	+	+++
Product/process	0	0	0	0

Note: +(-) =weakly significant (90%); ++(--) =strongly significant (95%); +++(---) =very strongly significant (99%); 0 =no significant relation
[a] expenses of training, marketing and acquisition of know-how

Source: Evangelista and Perani (1998)

LISREL-approach[31]

This section addresses the so-called LISREL-approach, to model and test the relationships between inputs, throughputs and outputs of the innovation process. LISREL refers to linear structural relationships and is a computer package that can be used to model equations. The LISREL-approach provides an opportunity to analyse micro-level data like the CIS-I and CIS-II in more detail. LISREL entails both the measurement and the explanation of innovative activities. The measurement part aligns with the main aim of the SIID project, which is to find indicators for innovative activities in service industries. The explanatory part tries to find causal relations between the core variable under consideration, *i.e.* innovative activities, and other variables that may explain the existence of innovative activities.

[31] This sub-section is mainly developed by Gjalt de Jong at the time he was working on this project.

Greiling (1998) has applied the LISREL-technique to a number of German and Polish manufacturing firms. We will discuss these results later. Below we will apply LISREL to a selected data set of CIS-I for the Dutch service sector. For the moment our data set only includes data on R&D, exporting activities and firm size. This section is only meant to survey the opportunities that LISREL offers to analyse micro data.

An analysis using LISREL consists of five sequential stages. Firstly, any LISREL-approach starts from a theoretical perspective. Secondly, based on the theoretical perspectives hypotheses are formulated. These hypotheses define the expected or causal relationships between these hypotheses. The combination of the hypotheses is an analytical, or in LISREL-terminology, a structural model. Thirdly, the data are collected and prepared for the analyses. Fourthly, the most appropriate tools from LISREL are selected. Fifthly, LISREL is applied and the empirical results are evaluated. These five stages are explained in more detail below.

Stage 1: Theoretical background

Little agreement exists about innovation concepts and their use in services. There are two main reasons for this. Firstly, the research topic has only recently been put on the agenda. It is only since the late 1980s that the importance of innovative activities in service industries is recognised. Secondly, most theories on innovation have been developed to study innovative activities in manufacturing. Many of these theories – including their concepts – are not directly applicable to service industries. Presently no unified theoretical model for the analysis of innovative activities in service industries exists. To some extent, lack of theory – or an analytical/theoretical model – complicates the process of data collection or selection of available data. A theoretical model with well-defined concepts and expected causalities between the concepts provides a useful point of departure for selection of available data.

Apart from the core concept of innovative activities (which represent the output of the innovation process), two other concepts that seem to be important in the literature on innovation, namely size of firm and exporting activities are taken on board in the present example. Large firm size and increased exports typically facilitate the innovation throughput. The next section combines the three constructs by means of two hypotheses in one analytical model.

Stage 2: Analytical model

The first explanatory variable we relate to innovative activities is the size of the firm. It has been often suggested that large firms have more opportunities for innovative activities than small firms do (Vossen, 1996). Firstly, there may be scale economies, which can be financial (i.e., a firm of a certain size is able to finance a particular project) or real (i.e., large firms have larger output over which to realise benefits of process innovations). Secondly, large firms can diversify the risks of performing innovative activities by maintaining a diversified portfolio of innovation projects. Thirdly, due to capital market imperfections, large firms can more easily obtain finance for risky projects. Finally, large firms may be in a better position to exploit the results of their research efforts, either because a large firm with an established name and reputation can more easily enter a new market, or because complementarities between innovative and other activities are better developed in larger firms. For instance, the value of innovative output may be greater for a large firm with well-developed marketing channels than for a small firm.

Exporting activities is the second explanatory variable that can be related to innovative activities. Firms that only produce for their national market are more likely to be oligopolists or monopolists and may lack incentives to innovate. Firms with exporting activities will have more competitors and thus have more incentives for innovative activities to continue their activities in the international markets.

These relationships are formulated in the following two hypotheses. Together, they construct the analytical model M_0, which is also presented in figure 3.

H1: Size of firm (throughput) will have a positive effect on innovative activities (output).

H2: Exporting activities (throughput) will have a positive effect on innovative activities (output).

Figure 3 - Model M_0 for Innovative Activities in Service Industries

Stage 3: Data

The data that are applied in the LISREL-approach are derived from the CIS-I (1992) for The Netherlands.[32] From the data respondents of 1,993 service firms have been selected for the present analysis. The selection criterion is item “sbi2” from the survey, which refers to the ‘Originele Kamer van Koophandel’ classification. This aligns with the Dutch ‘Standard Industrial Classification’ (SIC) numbers 40 – 99, which refer to service industries. From these firms, all cases with missing values on one of the items presented in Table 44 are deleted. Also, cases that report missing values on process and product innovations are deleted. The result is a sample size of 309 observations in the Dutch service industries.

Table 44 - Overview of Constructs and Items

Construct	Items
1. Innovative Activities	X1: Size R&D-activities 1992 within R&D department – years
	X2: Size R&D-activities 1992 within R&D department – money
	X3: Size R&D-activities 1992 other department R&D – years
	X4: Size R&D-activities 1992 other department R&D – money
	X5: Size R&D-activities 1992 outsourced R&D – years
	X6: Size R&D-activities 1992 outsourced R&D – money
2. Size of Firm	Number of Employees 1992
3. Exporting Activities	Export revenues exclusive taxes 1992

Source: Author's selection from CIS-I / SEO University of Amsterdam. See Brouwer *et al.* (1994)

CIS-I offers many items that can be used to make the three theoretical constructs operational. Table 44 presents the items that have been selected for this report. Six items (X1 to X6) have been selected which are expected to measure innovative activities. These items refer to the size of R&D activities in 1992. The other two constructs are measured by one item: size of firms in terms of number of employees, and exporting activities in terms of export revenues.

Stage 4: Method

This section summarises the main aspects of the LISREL-methodology.[33] LISREL distinguishes between latent and observed variables (Jöreskog and Sörbom, 1993). Latent variables represent unobservable theoretical constructs that can be measured by indicators or observed variables. Observed variables are the questions or items of a survey. A general LISREL model incorporates a measurement model and a structural model. These models may be estimated separately or simultaneously. The present case applies the latter opportunity.

A measurement model describes the relationship between a latent variable and its observed variables X_i and is analogous to factor analysis.[34] A structural model describes the

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[32] These data are kindly supplied by Erik Brouwer of the Stichting voor Economisch Onderzoek (SEO), University of Amsterdam.

[33] For details about LISREL and extensive empirical examples with respect to long-term supply relationships in the US, Japanese, and European automobile industry, see de Jong (1999).

[34] There are two forms of factor analysis namely exploratory and confirmatory factor analysis (henceforward EFA and CFA). EFA is the first step in the construct validation process. EFA helps to identify whether selected items cluster on one or on more than one factor, *i.e.* it helps to assess the unidimensionality of factors. We use SPSS for EFA because LISREL is not suitable for EFA. This is particularly relevant when three or more items are selected for a latent variable. Further, as part of EFA, standardized values of Cronbach's alpha are calculated. Cronbach's alpha is an often used measure of reliability for a set of two or more construct indicators; values range between 0 and 1 with higher values indicating higher reliability among indicators. In this study, .70 is used as the threshold

relationship between the different latent variables. The analytical model of Figure 3 is the structural model of this case. The model explicitly specifies the direction and sign of causality between the three latent variables. The main aim of the analysis of a structural model is to test whether hypothesised causalities do indeed occur. A hypothesis is confirmed if the estimated path coefficient is significant and has the hypothesised sign.[35]

LISREL offers different methods that can be used to estimate the models. This study uses the maximum likelihood estimation procedure. This method is most often applied in empirical studies because it has certain robust statistical features – *e.g.* ML estimates are consistent and are efficient. The ML estimation procedure requires an information matrix as input, which can be calculated with the computer package PRELIS. Several different input matrices can be computed, contingent on the measurement scale of the specific variables. If all variables are continuous ratio-scale variables, PRELIS computes a covariance matrix. However, if some – or even one – of the variables are measured on an ordinal scale, a correlation matrix is the most appropriate input matrix. This study applies a (Pearson) correlation matrix.

Stage 5: Empirical results

We start our empirical analyses with an exploratory factor analysis (EFA) for items X1 to X6. Given that we do not know *a priori* whether or not these items indeed measure one single construct, *i.e.* innovative activities, we have to find out. That is the main purpose of EFA.

Table 45 shows that the EFA for items X1-X6 results in two separate factors. The usual cut-off point for factor-loadings of .50 determines these two factors. Factor 1 is made operational by items X1, X2 and X4 and factor 2 by items X3 and X5. Given its low factor loadings of .22 and .04, item X6 does not construct either of the two factors. The standardised Cronbach’s alpha for items X1, X2, and X4 (factor 1) is .97, which is well above the required cut-off point of .70. For items X3 and X5 (factor 2) it is .06, which is far below the required cut-off point. Given these EFA results, only items X1, X2 and X4 are incorporated in further analyses. Hence, the EFA results suggest measuring the construct ‘innovative activities’ by items X1, X2, and X4. These items refer to the size of R&D activities within a firm’s R&D departments in terms of year (X1) and money (X2), and to the size of R&D activities in other R&D departments in terms of money (X4).

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value. CFA provides the ability to test the relationship between one indicator and the latent construct, which is not available from EFA. A relationship is significant if the estimated t-value is larger than 2. For both, the EFA and CFA, the factor-loadings should be larger than .50.

[35] This study uses one-tailed significance levels; a t-value larger than 1.645 corresponds to $p<.05$ (moderately significant) and a t-value larger than 2.326 to $p<.01$ (strongly significant).

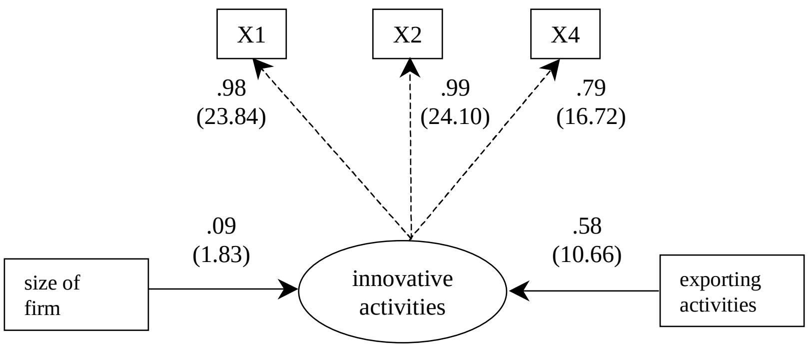
Table 45 - EFA Results for items X1-X6

Item	Factor 1	Factor 2
X1	**.97**	-.06
X2	**.97**	-.07
X3	.08	**.83**
X4	**.90**	.14
X5	-.06	**.57**
X6	.22	.04
Alpha	.97	.06

Source: Author's calculation from CIS-I / SEO University of Amsterdam

Next we turn to the confirmatory factor analysis (CFA) and hypotheses testing. We analyse these simultaneously. Using the three items X1, X2 and X4 for 'innovative activities' and the two items for the other two constructs (see Table 44) we apply PRELIS to calculate the (Pearson) correlation matrix. The (Pearson) correlation matrix serves as input matrix for maximum likelihood estimation procedure in LISREL. The estimates of the various path-coefficients (with their estimated t-values in brackets) are presented in figure 4.

Figure 4 - Measuring and Explaining Innovative Activities in Service Industries



Source: Author's calculation from CIS-I / SEO University of Amsterdam

Figure 4 presents the empirical results for measuring and explaining innovative activities in service industries. The measurement part is represented by the dotted lines, the explanatory part by the solid lines. Three conclusions can be drawn from these results.

Firstly, items X1, X2, and X4 are indeed reliable indicators for the latent construct 'innovative activities'. The estimates of the path coefficients – .98, .99, and .79 – are well above the required level of .50 and are significant because their t-values – 23.84, 24.10, and 16.72 – are much larger than 2. Hence, figure 2 provides a measure for innovative activities in service industries.

Secondly, hypothesis 1 is moderately confirmed by the data. The estimated path coefficient for hypothesis 1 is .09 with an estimated t-value of 1.83. Statistical explanations for the somewhat low t-value maybe the non-normal distribution of the variable ‘size of firm’. The ML estimation procedure of LISREL underestimates t-values in case non-normality occurs. Nevertheless, these results show that firm size indeed has a positive effect on innovative activities as expected.

Thirdly, hypothesis 2 is strongly confirmed by the data. The estimated path-coefficient for hypothesis 2 is .58 with an estimated t-value of 10.66. This means that the firm’s exporting activities positively influences the firm’s innovative activities. This provides a second explanation for innovative activities in Dutch service industries.

Scope for further research with LISREL

The LISREL-analysis described above is of a preliminary nature. Provided the data are available in the right format, it is a possible route to follow in analysing aspects of innovation using micro-level data. There are a number of details that need to be taken into account before applying LISREL. First, LISREL can only validly be used in case of linear relations. Second, the dependent variable should be a continuous variable and not be truncated in any way (*e.g.* to positive values only) or be dichotomous (only two outcomes, *e.g.* ‘yes’ or ‘no’). These variables are estimated more reliably with Tobit regressions, in case of a truncated variable, or Probit and Logit regressions in case of dichotomous variables. Since many innovation indicators are of the truncated or dichotomous type, possibilities for LISREL seem limited.

On the other hand, when these requirements are fulfilled (*i.e.* linear relations and continuous dependent variables) LISREL can be applied in case a large number of mutually dependent (linear) relations need to be estimated simultaneously and may offer opportunities for further research. Firstly, adding new constructs and new hypotheses may develop a theory of innovation. Secondly, there is an ongoing debate on whether or not R&D figures actually measure innovation. The CIS-I and CIS-II surveys identify a range of other indicators of innovative activity besides R&D. Thirdly, the LISREL model may be re-estimated with a new sample from the Dutch CIS-I or CIS-II. Furthermore, the Dutch samples may be stratified in specific service industries - *e.g.* wholesale trade, transport, and financial services. The latter would offer an opportunity to analyse differences in innovative activities between different service industries. Provided of course that sufficient observations per stratum remain. Finally, the analytical model may be re-estimated with a new – stratified or not – sample from service industries outside The Netherlands (again derived from the CIS-I and CIS-II surveys). This would offer an opportunity to study international differences in service industries.

To illustrate the role of LISREL in other research on innovation, we refer to Greiling (1998) who conducted an in-depth analysis of the ability to innovate for medium-sized (*i.e.*

between 50-500 employees) German and Polish manufacturing firms using LISREL. Whereas the example above identified innovative activities in services industries based on several R&D measures, Greiling uses a host of other items to identify innovative ability of manufacturing firms. Instead of our concept 'innovative activities', Greiling's concept is 'innovative ability'. It involves all possibilities and opportunities that firms have to create innovations. Innovations are regarded as improvements instigated and/or implemented, be it from one person or a group of persons within the firm. Innovative ability is hence defined as the possibilities of a firm to search, recognise, formulate, evaluate and implement innovations.

Greiling uses a large number of items that affect the concept of 'innovative ability'. The latent construct 'innovative ability' itself is determined by the results of innovations. The innovative ability is assumed to be influenced by a large number of firm characteristics. Table 44 gives a summary of these items. The LISREL-approach is used to determine which of these items are important in describing this innovative ability. In order to obtain relevant data, Greiling constructed a large questionnaire that identified the innovation results per firm and all items listed in Table 46. In fact every single item corresponds to a different set of questions. This questionnaire was sent to firms in the German and Polish manufacturing sector. Hence no attention is paid to innovative ability of other sectors in the economy, like services. The study include 52 German and 53 Polish manufacturing firms.

The conclusions from this study are that the items: 'configuration' (X6.4), 'delegation of power of decision' (X6.5) and 'political-judicial factors' (X8.1) and 'social-cultural factors' (X8.2) turn out to be less important in explaining 'innovative ability'. The item 'management style' (X1) could not be adequately identified with the existing data material. The quality of the workforce has an effect on innovative ability only in Germany and not in Poland. The following hypotheses constructed from the various items in Table 46 together do capture the concept of innovative ability:

- the higher specialisation, the higher the ability to innovate (X6.1)
- the higher formalisation, the higher the ability to innovate (X6.2)
- the less standardisation, the higher the ability to innovate (X6.3)
- the more successful a firm is in achieving its goals, the higher the ability to innovate (X2)
- the higher the contents of information and communication inside the firm, the higher the ability to innovate (X7.2)
- the more sources of information and communication are used, the higher the ability to innovate (X7.3)
- the higher the level of education of the workforce, the higher the ability to innovate (X5)
- the more workers are involved in the firm, the higher the ability to innovate (X5)

- the less working experience of workers, the higher the ability to innovate (X5)
- the more willing workers are to be involved with innovations, the higher the ability to innovate (X5)
- the more incentives play a role in the firms, the higher the ability to innovate (X4)
- the more the incentives at the individual level, the higher the ability to innovate (X4)
- the more intense the contacts and co-operation between firms is, the higher the ability to innovate (X3)
- the more environmental protection measures are seen as a risk, the higher the ability to innovate (X8.3)

Table 46 - Items determining the ability to innovate

Construct	Items
Innovative Ability	X1: Management style of the firm
	X2: Rate of success of the firm in achieving goals
	X3: Co-operation with other firms
	X4: Incentives, both monetary (wages) and non-monetary
	X5: Quality of workforce and willingness to join in innovations
	X6: Organisational structure of the firm, consisting of:
	- X6.1: specialisation
	- X6.2: formalisation
	- X6.3: standardisation
	- X6.4: configuration
	- X6.5: delegation of power of decision
	- X6.6: co-ordination
	X7: Information and communication within the firm, w.r.t:
	- X7.1: direction
	- X7.2: contents
	- X7.3: sources
	X8: Impact of the government, in the sense of:
	- X8.1: political-judicial factors
	- X8.2: social-cultural factors
	- X8.3: environmental factors

Source: Greiling, 1998, pp. 238.

A number of other items that were thought to be of interest to identify innovative ability were included initially, but were later removed from the analysis for various reasons. One of these items was the size of the firm. This was excluded because only medium-sized firms were included in the analysis. Something similar applies to items like ‘regional aspects’ and ‘possibility of the firm to attain financing’.

4. SUMMARY AND CONCLUSIONS

This paper had a twofold aim. Firstly, it presented an overview of sources on data on service innovation, where we distinguished between typical macro-data (like output, employment, capital and inter-industry flows of intermediate inputs and investment) and micro-data (like the firm data from specific innovation surveys). Secondly, the paper provided some analytical structures that can assist in analysing the data, including – at the macro level – growth accounting and input-output analysis, and – at the micro level – regression analysis and the LISREL-approach.

Section 2 of the paper provided an extensive overview of the availability of macro- and micro-data on service innovation. Most macro-data do not measure the service innovation process itself, but mainly represent inputs in or output originating from the innovation process. Serious measurement problems affect the estimates of service output, and further research should focus to improve estimates in the finance sector and non-market services in particular. The micro-data, in particular those from the innovation surveys, provide more detail on innovation, but the coverage of services is still weak. Results from the second Community Innovation Survey (CIS-II) need to be awaited to see the progress made on monitoring innovation in services.

Still the present data at macro- and micro level already provide some important notions on service innovation. Section 3 of the paper analysed the data from this perspective in some more detail. The following conclusions and suggestions for further research arise from the analysis.

Firstly, it is clear from the data that there is a huge heterogeneity in service performance and the role of service innovation. Future research should therefore always address the role of different service industries. Aggregated data – even at the level of six service industries distinguished in the macro data-set - may hide too much of the details. In this respect the classification of service industries needs to be considered. Clearly, Pavitt (1984) introduced a very helpful taxonomy for characterising the innovation performance of various categories of firms differentiating between science-based firms, scale-intensive firms, specialised equipment producers and supplier dominated firms. However, in this taxonomy services are simply classified as mainly supplier dominated. Soete and Miozzo (1989) elaborated on the Pavitt taxonomy by making a distinction between supplier dominated services, scale intensive service sectors (large scale processes such as major back office administrative tasks or the operation of physical networks), network sectors (services that depend on elaborate information networks), and specialised technology suppliers and science-based sectors (such as suppliers of software and specialised business services). More recently, as services have been included in innovation surveys, new taxonomies have popped up distinguishing between science and technology (S&T)-based services (*e.g.* R&D services, engineering services), technology-using services (*e.g.* transport, travel, security, cleaning), consultancy-type services (technical consultancy) and more interactive services in which interactions with clients are key (*e.g.* financial services, trade, advertising). Provided that data – in particular at the macro level – are almost exclusively available on the basis of the standard industrial classifications, concordances with new taxonomies that facilitate the analysis of service innovations are required.

A second observation is that, despite heterogeneity, productivity growth in services has slowed down during the period 1985-1996 compared to the period 1973-1985. However, only for the United States the service productivity slowdown could be seen as a clear contributor to the overall slowdown of productivity growth in the economy. In fact labour productivity growth was relatively fast in the European countries compared to the USA, even though the productivity levels were still below the U.S. level. However, the productivity differentials not only represent differences in efficiency and innovative capacity, but also differences in functioning of markets in each of the countries, which in turn affects the potential for innovations in the sector that stimulate output and productivity growth.

Thirdly, even though the micro-level innovation surveys give an important role to product innovation in services, both the micro and the macro surveys suggest that investment in services is a major carrier of new technologies, which leads to process innovation in the service sector. Both physical and human capital intensity are high in the European services relative to those in the United States, which in combination with the lower labour productivity levels observed above suggest a lower efficiency use of physical and human capital in Europe. The micro-surveys also indicate the heavy use of information and communication technology (ICT) in services, which is a more important input in the production process in services than in manufacturing. This raises major questions on the nature and interpretation of the productivity paradox. In terms of intermediate input use, services have become more intertwined with each other than with non-service sectors.

Fourthly, innovation data are still dominated by figures on R&D and patents, which are of limited use for the analysis of service innovation. Despite the limitations, it appears that R&D services and computer services are among the biggest R&D spenders in services. There is some evidence from Dutch innovation surveys for 1988 and 1992 that R&D activity in manufacturing is falling whereas that in services it is increasing. The most recent innovation surveys have contributed to generating alternative data, but the usefulness of these data for analysis in services is still uncertain. It appears necessary to consider whether the innovation models used for manufacturing can also be used in services. For this reason it is worth investigating whether analysis of new data, for example CIS-II, can be carried out within the framework of the LISREL-approach introduced in this paper. LISREL can simultaneously measure innovation and establish the causal relations between the core (or latent) variables, *e.g.* services innovation, and explanatory variables. An advantage of the LISREL-approach is that it can relatively easily derive equations that can be used further to establish theoretical relationships pertaining to innovations. Note, however, that latent constructs are, even in the LISREL-approach, related to items that are measurable. This is inevitable since only measurable variables can be related. In that way we still end up with a sort of standard regression analysis. Additional drawbacks are the specific prerequisites of the data, variables and relations have to be fulfilled in order to perform LISREL

The following suggestions for further research emerge from this overview:

1) More work on measurement problems in services, in particular in finance, business services and non-market services, like health and education. Co-operation with statistical institutes (such as Statistics Netherlands), international organisations (such as OECD) and with American scholars (for example, at the Brookings Institution, where an extension programme on measurement of service productivity is in place) is of crucial importance.
2) Development of a concordance between standard industrial classifications and taxonomies that are better suitable for analysis of service innovation.
3) Analysis of the relation between market structures, physical and human capital intensity, innovation capacity and productivity performance in service sectors.
4) Integration of growth accounting and input-output analysis to strengthen research on the role of investment, in particular in ICT, as carriers of innovation activities in services. This work can be integrated with other ongoing work on growth accounting in which the University of Groningen is involved
5) In order to establish causal relationships between innovation measures and the overall concept of innovation in services, and to investigate whether these relationships are fundamentally different from those in manufacturing, it is recommended to investigate the possibilities LISREL offers and if necessary develop this approach in innovation research. In particular the new data that will come out of CIS-II can be used for this purpose.
6) Finally the link between innovation and economic performance can also be analysed from both the macro and the micro-level. One possible link is between information on the role of ICT equipment in various industries and economic performance of those industries. Another possible link is between micro-data from the innovation surveys or automation surveys and production censuses or employment surveys.

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Annex A – Statistics of service output, employment and productivity

The Groningen Growth and Development Centre (GGDC) at the Faculty of Economics of University of Groningen was founded in 1992 with the aim to strengthen empirical research in the field of economic growth. Over the years, large data bases have been developed which may be divided into the following three subsets of data:

1) The GGDC Total Economy Database included data on GDP, employment and hours for about 60 countries since 1950. For a limited number of OECD countries it also includes data on physical and human capital. The Total Economy Database has been largely built upon data from Maddison (1995), but the statistics since 1990 have been updated on annual basis.
2) The GGDC Sectoral Data Base includes statistics on GDP, employment and (for a limited number of countries) physical and human capital for 10 major sectors of the economy for about 10 OECD countries since 1950 and another 6 Asian countries since 1960. It builds upon earlier work for OECD countries by Van Ark (1996b) but the statistics are expanded and updated on an annual basis.
3) The International Comparisons of Output and Productivity (ICOP) project focuses on international comparisons of output and productivity levels by industry. Its main characteristic is the use of industry-specific purchasing power parities (or unit value ratios) to convert output levels to a common currency (see van Ark, 1993, 1996a). The major variables in the ICOP database are gross output, value added, employment, hours, productivity and prices by industry in an international comparative perspective. Most ICOP studies so far have concentrated on the commodity sectors of the economy (in particular manufacturing), which now cover about 30 countries in Asia, East and Western Europe, and North and South America. Recently the first ICOP studies for services have emerged, including one on productivity in transport and communication, and wholesale and retail trade in Canada, France, Germany and The Netherlands relative to the United States (Van Ark, Monnikhof and Mulder, 1999).

In the near future substantial series from the GGDC and ICOP databases will be made available on the Internet site of the Groningen Growth and Development Centre (http://www.eco.rug.nl/ggdc.html).

Table A.1. Share of service industries in total GDP in constant prices

		%-Share in Total GDP					
		Wholesale and Retail Trade	Transport and Communi-cation	Finance, Insurance and Real Estate	Community, Social and Personal Services	Govern-ment Services	Total Service Sector
France	1973	14	5	15	6	17	57
	1985	13	7	18	7	17	62
	1996	12	8	20	8	17	66
Germany	1973	9	5	11	11	13	50
	1985	9	6	13	15	14	56
	1996	9	7	15	21	13	66
The Netherlands	1973	16	7	7	12	14	56
	1985	17	8	12	12	14	62
	1996	17	9	14	12	12	64
United States	1973	14	6	13	13	13	59
	1985	17	6	15	15	11	64
	1996	19	7	14	16	9	66
United Kingdom	1973	14	7	14	4	16	54
	1985	13	7	18	5	16	59
	1996	14	8	21	5	13	62

Sources: GGDC Sectoral data Base, University of Groningen

Table A.2. Share of service industries in total hours worked

		%-Share in Total GDP					
		Wholesale and Retail Trade	Transport and Communi-cation	Finance, Insurance and Real Estate	Community, Social and Personal Services	Govern-ment Services	Total Service Sector
France	1973	13	5	6	6	18	49
	1985	14	6	9	9	22	60
	1996	14	6	12	11	25	69
Germany	1973	13	6	2	9	15	45
	1985	13	6	3	13	19	54
	1996	14	6	3	19	20	62
The Netherlands	1973	20	7	9	8	11	55
	1985	18	7	12	13	14	65
	1996	19	7	17	15	12	71
United States	1973	20	5	5	18	17	65
	1985	21	4	6	22	16	69
	1996	21	5	6	27	15	73
United Kingdom	1973	17	7	6	5	18	53
	1985	19	6	9	8	21	64
	1996	20	6	13	13	19	71

Sources: GGDC Sectoral data Base, University of Groningen

Annex B – OECD statistics that include measures of service innovation

The OECD is one of the main institutes that offer international comparative data that can be used for international comparisons of service innovation. In particular, there are 11 Science databases among which *e.g.* the AFA (Activities of Foreign Affiliates), the ANBERD (Analytical Business Enterprise Research and Development), and the BTD Bilateral Trade database. Further details on these and other databases managed by OECD's Directorate for Science, Technology and Industry (DSTI) can be found at the following internet address: <http://www.oecd.org/dsti>. All 11 Science databases cover the nine countries for the SIID project except for Denmark, which is not covered in the AFA database, and Belgium, which is not covered in the AFA and the ANBERD databases.

For the most part, the 11 Science databases cover macro level and output oriented indicators. Furthermore, these databases are dominated by manufacturing industries. Nevertheless, the next six databases may provide useful information with respect to service industries. Many of the following sections of this report use these or similar data.

- **ANBERD** – The Analytical Business Enterprise Research and Development database is an estimated database constructed with the objective of creating a consistent data set that overcomes the problems of international comparability and time discontinuity associated with the official business enterprise R&D data provided to the OECD by its Member countries. ANBERD contains R&D expenditures for the period 1973-95, by industry, for 15 OECD member countries. Publication: OECD (1997), *Research and Development Expenditure in Industry: 1974-95.*
- **I-O** – The Input-Output database contains flow matrices of intermediate and final goods (both domestic and imported) for selected years in the 1970-90 period. It covers ten countries and 36 industries of which 22 are in the manufacturing sector. Publication: OECD (1996), *The OECD Input-Output Database.* There are also separate tables on investment flows.
- **ISDB** – The International Sectoral Database combines a range of data series related to sectoral output and primary factor inputs (labour and capital) in a manner compatible with the OECD National Accounts Statistics. It covers the period 1960-96 for 15 OECD countries. Major variables included are: gross domestic product, total employment (persons engaged) and employees, gross fixed capital formation and gross capital stock, compensation of employees, consumption of fixed capital, gross operating surplus, and net indirect taxes. Most data are available in both current and constant (1990) prices. It should be noted that the ISDB has some similarities with the GGDC sectoral database at

the University of Groningen and the NIESR Productivity Database. Publication: OECD (1997), *International Sectoral Database – 1997 edition* (available on diskette only).

- **ISIS** – The Industrial Structure Database provides official annual data derived from industrial surveys, foreign trade and national accounts. It covers manufacturing and non-manufacturing industries at a detailed level of disaggregation (4 digits according to ISIC Revision 2), for variables such as production, value added, investment, investment in machinery and equipment, exports, imports, wages and salaries, employment, number of establishments and hours worked. As of the 1997 edition, ISIS also contains data in the new international industry classification, ISIC Revision 3. Publication: OECD (1997), *Industrial Structure Statistics – 1997 edition.*
- **MSTI** – The Main Science and Technology Indicators database provides a selection of the most frequently used annual data on the scientific and technological performance of OECD Member Countries as of 1981. Of the 89 indicators included, 70 deal with resources devoted to R&D, and 19 are experimental indicators of the output and impact of S&T activities (patents, technology balance of payments, and trade of high-technology industries). Publication: OECD (1997), *Main Science and Technology Indicators*, 1997/1/2.
- **S&T Databases –** This set of databases includes the R&D database, which contains the full results of surveys on the resources devoted to R&D by OECD countries as of 1963. It provides a detailed breakdown of R&D expenditures by funding and performance and data on R&D personnel by occupation and level of qualification. It also includes information on intended government R&D financing, which shows the government budget appropriations or outlays for R&D broken down by socio-economic objective. The S&T databases also include data on patents and the technology balance of payments and provide the primary data for the ANBERD and MSTI databases. Publication: OECD (1997), *Basic Science and Technology Statistics – 1997 Edition.*
- **STAN** – The Structural Analysis database is an estimated database which has been developed to ensure international comparability of survey-based national industrial statistics and their comparability with national accounts. It contains eight variables: production, value added (in constant and current prices), gross fixed capital formation, number of persons engaged, labour compensation, exports, and imports. The database covers 22 OECD countries and 49 manufacturing sectors. Data are available for the period 1970-95. Publication: OECD (1997), *The OECD STAN Database for Industrial Analysis: 1976-95.*

Annex C - Input-output tables and capital flow matrices

The figures are derived from the OECD Input-Output Database (1995). See Annex B for further details. We used the IO tables for domestic and imported intermediate inputs and domestic and imported capital formation in constant prices.

The data are represented below as follows. The rows of the tables show the deliveries of manufacturing (high-tech, medium-tech and low-tech), services and other non-manufacturing industries to various service industries (the columns of the tables). Tables of the intermediate goods produced (as output) by manufacturing firms, services or others and act as input in the various service industries, as percentage of total input of the receiving service industry, are listed in Tables C1. We can also look at investment goods by origin and destination in the same way. The industries that produce investment goods for service industries are again high-tech, medium-tech and low-tech manufacturing, services and other non-manufacturing services. The share of investment goods originating from one of these sectors and used as input in service industries, as share of total investment of that service industry is listed in Tables C2. In fact the Tables C1 show the flow of goods from one industry (output) to the other (input), while the Tables C2 show the flow of capital goods from one industry (output) to the other (input), as a share of total input. The last row of the Tables C1 lists the share of total inputs from other industries in the total output of the service industry under consideration.

All data in Tables C are in constant (1985) prices. Capital flow figures for the USA are only available in constant prices for 1972 and 1977. Tables of the capital flows in current prices are available up to 1990 for the USA, but with these tables we cannot disentangle the price effect from the quantity effect. Hence, the shares of tables in current prices become meaningless.

Finally, we report the industries that build high-tech, medium-tech and low-tech manufacturing. High-tech industries include aircraft, office & computing equipment, drugs and medicine and radio, TV and communication equipment. Medium-high tech industries include professional goods, motor vehicles, electrical machines (exc. communication equipment), chemicals (exc. drugs), transport equipment and non-electrical machinery. Medium-low tech industries include rubber and plastic products, shipbuilding, other manufacturing, non-ferrous metals, non-metallic mineral products, metal products, petroleum refineries and ferrous metals. Low-tech industries include paper products and printing, textiles, apparel and leather, food, beverages and tobacco, and wood furniture.

Table C1.1. Share of input in services from the output of other sectors, Germany

	Wholesale and retail trade				Hotels and restaurants			
	1978	1986	1988	1990	1978	1986	1988	1990
Manufacturing								
low-tech	0.17	0.14	0.14	0.13	0.53	0.50	0.55	0.46
medium-tech	0.04	0.03	0.04	0.03	0.03	0.02	0.03	0.03
high-tech	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.02
Other non-services	0.07	0.08	0.08	0.07	0.15	0.10	0.11	0.09
Services	0.69	0.72	0.71	0.75	0.28	0.35	0.31	0.40
Total inputs/total outputs	0.38	0.40	0.38	0.39	0.59	0.64	0.63	0.63

	Transport and storage				Communication			
	1978	1986	1988	1990	1978	1986	1988	1990
Manufacturing								
low-tech	0.29	0.23	0.24	0.23	0.12	0.09	0.09	0.08
medium-tech	0.09	0.07	0.07	0.07	0.03	0.03	0.03	0.03
high-tech	0.01	0.03	0.03	0.03	0.06	0.09	0.08	0.10
Other non-services	0.06	0.04	0.04	0.04	0.10	0.07	0.08	0.06
Services	0.54	0.62	0.61	0.62	0.69	0.71	0.71	0.71
Total inputs/total outputs	0.52	0.55	0.55	0.51	0.19	0.18	0.18	0.22

	Finance and insurance				Real estate and business services			
	1978	1986	1988	1990	1978	1986	1988	1990
Manufacturing								
low-tech	0.09	0.06	0.07	0.06	0.10	0.08	0.08	0.07
medium-tech	0.03	0.02	0.02	0.02	0.06	0.05	0.06	0.06
high-tech	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.04
Other non-services	0.04	0.04	0.04	0.03	0.21	0.16	0.17	0.14
Services	0.80	0.84	0.83	0.85	0.52	0.63	0.60	0.65
Total inputs/total outputs	0.26	0.28	0.29	0.28	0.29	0.32	0.31	0.34

	Community, social and personal services			
	1978	1986	1988	1990
Manufacturing				
low-tech	0.42	0.36	0.37	0.36
medium-tech	0.07	0.05	0.05	0.05
high-tech	0.11	0.11	0.11	0.10
Other non-services	0.03	0.02	0.02	0.02
Services	0.35	0.44	0.43	0.45
Total inputs/total outputs	0.43	0.46	0.46	0.47

Table C1.2. Share of input in services from the output of other sectors, The Netherlands

	Wholesale and retail trade				Hotels and restaurants			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.20	0.19	0.17	0.16	0.48	0.45	0.45	0.43
medium-tech	0.03	0.04	0.03	0.04	0.02	0.02	0.02	0.02
high-tech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other non-services	0.05	0.05	0.05	0.06	0.11	0.11	0.11	0.15
Services	0.70	0.71	0.73	0.74	0.38	0.37	038	0.39
Total inputs/total outputs	0.26	0.30	0.29	0.32	0.43	0.42	0.43	0.44

	Transport and storage				Communication			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.29	0.33	0.32	0.28	0.24	0.22	0.23	0.23
medium-tech	0.07	0.06	0.06	0.07	0.11	0.12	0.11	0.11
high-tech	0.02	0.02	0.02	0.03	0.06	0.03	0.04	0.04
Other non-services	0.09	0.09	0.09	0.07	0.12	0.12	0.12	0.06
Services	0.51	0.48	0.50	0.50	0.40	0.46	0.48	0.51
Total inputs/total outputs	0.28	0.29	0.30	0.30	0.15	0.17	0.15	0.14

	Finance and insurance				Real estate and business services			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.10	0.10	0.11	0.10	0.14	0.14	0.12	0.12
medium-tech	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.03
high-tech	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Other non-services	0.06	0.06	0.06	0.06	0.42	0.42	0.42	0.31
Services	0.80	0.79	0.79	0.80	0.39	0.44	0.50	0.50
Total inputs/total outputs	0.28	0.25	0.25	0.27	0.16	0.16	0.16	0.16

	Community, social and personal services			
	1972	1977	1981	1986
Manufacturing				
low-tech	0.21	0.19	0.17	0.16
medium-tech	0.17	0.16	0.16	0.16
high-tech	0.07	0.08	0.07	0.09
Other non-services	0.16	0.16	0.16	0.13
Services	0.39	0.41	0.45	0.44
Total inputs/total outputs	0.22	0.24	0.26	0.27

Table C1.3. Share of input in services from the output of other sectors, USA

	Wholesale and retail trade					Hotels and restaurants				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.16	0.13	0.15	0.12	0.11	0.52	0.49	0.48	0.46	0.38
medium-tech	0.02	0.03	0.02	0.02	0.05	0.02	0.03	0.03	0.03	0.04
high-tech	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Other non-services	0.11	0.10	0.10	0.10	0.10	0.12	0.12	0.11	0.12	0.14
Services	0.71	0.73	0.71	0.76	0.72	0.35	0.35	0.37	0.39	0.43
Tot. inp./tot. outp.	0.27	0.32	0.30	0.32	0.27	0.50	0.49	0.54	0.53	0.52

	Transport and storage					Communication				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.27	0.26	0.29	0.24	0.18	0.07	0.07	0.07	0.07	0.05
medium-tech	0.05	0.06	0.05	0.05	0.05	0.01	0.05	0.04	0.04	0.03
high-tech	0.03	0.02	0.02	0.03	0.03	0.09	0.10	0.16	0.09	0.15
Other non-services	0.11	0.11	0.09	0.08	0.08	0.23	0.21	0.20	0.23	0.14
Services	0.53	0.52	0.50	0.60	0.59	0.57	0.52	0.45	0.56	0.49
Tot. inp./tot. outp.	0.46	0.43	0.52	0.40	0.44	0.24	0.23	0.21	0.27	0.22

	Finance and insurance					Real estate and business services				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.09	0.06	0.06	0.06	0.05	0.09	0.06	0.07	0.07	0.06
medium-tech	0.01	0.01	0.01	0.00	0.00	0.04	0.01	0.02	0.01	0.02
high-tech	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.04
Other non-services	0.05	0.04	0.04	0.05	0.03	0.26	0.30	0.20	0.19	0.20
Services	0.86	0.88	0.87	0.88	0.90	0.59	0.62	0.69	0.71	0.68
Tot. inp./tot. outp.	0.45	0.40	0.50	0.47	0.48	0.24	0.22	0.21	0.27	0.28

	Community, social and personal services				
	1972	1977	1980	1985	1990
Manufacturing					
low-tech	0.14	0.14	0.14	0.13	0.12
medium-tech	0.17	0.12	0.13	0.12	0.10
high-tech	0.05	0.06	0.06	0.06	0.07
Other non-services	0.15	0.16	0.16	0.14	0.13
Services	0.48	0.51	0.51	0.55	0.57
Tot. inp./tot. outp.	0.40	0.39	0.41	0.36	0.45

Table C1.4. Share of input in services from the output of other sectors, UK

	Wholesale and retail trade				Hotels and restaurants			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.29	0.22	0.20	0.23	0.29	0.40	0.60	0.45
medium-tech	0.09	0.11	0.12	0.12	0.09	0.02	0.03	0.02
high-tech	0.08	0.03	0.02	0.03	0.01	0.00	0.00	0.01
Other non-services	0.12	0.12	0.11	0.05	0.18	0.11	0.16	0.13
Services	043	0.50	0.55	0.57	0.43	0.47	0.20	0.39
Total inputs/total outputs	0.26	0.39	0.42	0.57	0.27	0.53	0.36	0.46

	Transport and storage				Communication			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.16	0.33	0.30	0.14	0.16	0.10	0.13	0.09
medium-tech	0.11	0.11	0.13	0.05	0.03	0.04	0.05	0.10
high-tech	0.05	0.03	0.03	0.05	0.24	0.23	0.35	0.26
Other non-services	0.03	0.03	0.03	0.04	0.06	0.07	0.10	0.04
Services	0.65	0.49	0.50	0.74	0.51	0.55	0.36	0.51
Total inputs/total outputs	0.41	0.69	0.57	0.51	0.20	0.29	0.26	0.46

	Finance and insurance				Real estate and business services			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.45	0.18	0.14	0.14	0.35	0.14	0.12	0.15
medium-tech	0.06	0.05	0.04	0.02	0.25	0.13	0.08	0.05
high-tech	0.03	0.02	0.02	0.02	0.07	0.02	0.04	0.06
Other non-services	0.04	0.13	0.09	0.04	0.07	0.28	0.16	0.04
Services	0.42	0.63	0.71	0.78	0.27	0.43	0.61	0.71
Total inputs/total outputs	0.33	0.35	0.43	0.69	0.14	0.13	0.17	0.52

	Community, social and personal services			
	1968	1979	1984	1990
Manufacturing				
low-tech	0.21	0.19	0.17	0.16
medium-tech	0.17	0.16	0.16	0.16
high-tech	0.07	0.08	0.07	0.09
Other non-services	0.03	0.09	0.10	0.12
Services	0.27	0.54	0.61	0.61
Total inputs/total outputs	0.11	0.19	0.29	0.34

Table C1.5. Share of input in services from the output of other sectors, France

	Wholesale and retail trade					Hotels and restaurants				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.14	0.14	0.12	0.11	0.10	0.46	0.47	0.43	0.40	0.39
medium-tech	0.06	0.05	0.05	0.04	0.04	0.01	0.01	0.01	0.01	0.01
high-tech	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Other non-services	0.05	0.05	0.04	0.05	0.05	0.17	0.15	0.16	0.17	0.17
Services	0.75	0.74	0.78	0.78	0.79	0.37	0.37	0.39	0.42	0.44
Tot. inp./tot. outp.	0.24	0.24	0.28	0.29	0.31	0.37	0.43	0.46	0.43	0.46

	Transport and storage					Communication				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.35	0.33	0.30	0.27	0.24	0.13	0.12	0.10	0.08	0.07
medium-tech	0.07	0..06	0.06	0.06	0.06	0.04	0.04	0.03	0.03	0.03
high-tech	0.02	0.02	0.01	0.02	0.02	0.14	0.16	0.13	0.12	0.12
Other non-services	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.05
Services	0.52	0.54	0.58	0.61	0.64	0.64	0.64	0.70	0.73	0.72
Tot. inp./tot. outp.	0.39	0.40	0.42	0.41	0.42	0.21	0.20	0.19	0.16	0.13

	Finance and insurance					Real estate and business services				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.15	0.15	0.08	0.06	0.02			0.16	0.15	0.14
medium-tech	0.02	0.02	0.01	0.00	0.00			0.02	0.01	0.02
high-tech	0.03	0.03	0.00	0.00	0.00			0.04	0.05	0.05
Other non-services	0.05	0.05	0.12	0.11	0.04			0.02	0.03	0.02
Services	0.76	0.76	0.79	0.82	0.93			0.76	0.77	0.78
Tot. inp./tot. outp.	0.26	0.27	0.26	0.34	0.61			0.30	0.30	0.34

	Community, social and personal services				
	1972	1977	1980	1985	1990
Manufacturing					
low-tech	0.33	0.32	0.29	0.27	0.26
medium-tech	0.10	0.10	0.10	0.09	0.09
high-tech	0.05	0.05	0.05	0.04	0.04
Other non-services	0.05	0.05	0.05	0.06	0.05
Services	0.47	0.49	0.51	0.54	0.55
Tot. inp./tot. outp.	0.25	0.29	0.30	0.29	0.29

Table C2.1. Share of investment from various sectors, used as input in services, Germany

	Wholesale and retail trade			Hotels and restaurants		
	1978	1986	1990	1978	1986	1990
Manufacturing						
low-tech	0.13	0.14	0.14	0.14	0.16	0.14
medium-tech	0.26	0.32	0.26	0.24	0.38	0.39
high-tech	0.12	0.13	0.21	0.08	0.05	0.06
Other non-services	0.40	0.32	0.30	0.46	0.33	0.32
Services	0.09	0.08	0.08	0.08	0.08	0.08

	Transport and storage			Communication		
	1978	1986	1990	1978	1986	1990
Manufacturing						
low-tech	0.27	0.22	0.21	0.04	0.04	0.03
medium-tech	0.17	0.20	.019	0.04	0.02	0.02
high-tech	0.12	0.14	0.28	0.42	0.51	0.57
Other non-services	0.35	0.37	0.28	0.40	0.36	0.31
Services	0.09	0.06	0.05	0.09	0.07	0.06

	Finance and insurance			Real estate and business services		
	1978	1986	1990	1978	1986	1990
Manufacturing						
low-tech	0.08	0.07	0.07	0.09	0.07	0.06
medium-tech	0.11	0.15	0.14	0.04	0.10	0.17
high-tech	0.25	0.26	0.31	0.03	0.11	0.11
Other non-services	0.47	0.43	0.39	0.78	0.65	0.58
Services	0.08	0.08	0.08	0.06	0.07	0.07

	Community, social and personal services		
	1978	1986	1990
Manufacturing			
low-tech	0.07	0.08	0.08
medium-tech	0.22	0.03	0.03
high-tech	0.31	0.03	0.04
Other non-services	0.30	0.80	0.78
Services	0.10	0.06	0.06

Table C2.2. Share of investment from various sectors, used as input in services, Netherlands

	Wholesale and retail trade				Hotels and restaurants			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.09	0.10	0.09	0.10	0.08	0.09	0.06	0.03
medium-tech	0.23	0.29	0.28	0.32	0.34	0.27	0.20	0.23
high-tech	0.07	0.07	0.11	0.14	0.04	0.06	0.08	0.08
Other non-services	0.46	0.37	0.34	0.25	0.36	0.39	0.46	0.45
Services	0.16	0.18	0.20	0.22	0.18	0.18	0.20	0.21

	Transport and storage				Communication			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.13	0.15	0.12	0.14	0.18	0.19	0.16	0.14
medium-tech	0.46	0.45	0.41	0.40	0.29	0.31	0.27	0.28
high-tech	0.10	0.09	0.13	0.16	0.21	0.22	0.23	0.27
Other non-services	0.31	0.17	0.20	0.16	0.18	0.12	0.13	0.12
Services	0.15	0.18	0.19	0.22	0.14	0.16	0.21	0.19

	Finance and insurance				Real estate and business services			
	1972	1977	1981	1986	1972	1977	1981	1986
Manufacturing								
low-tech	0.06	0.06	0.06	0.04	0.01	0.00	0.00	0.00
medium-tech	0.10	0.11	0.10	0.10	0.00	0.00	0.00	0.00
high-tech	0.09	0.09	0.10	0.11	0.02	0.02	0.02	0.02
Other non-services	0.62	0.60	0.61	0.63	0.84	0.80	0.82	0.83
Services	0.13	0.13	0.13	0.13	0.13	0.17	0.15	0.15

	Community, social and personal services			
	1972	1977	1981	1986
Manufacturing				
low-tech	0.09	0.09	0.07	0.07
medium-tech	0.26	0.22	0.17	0.19
high-tech	0.07	0.08	0.09	0.12
Other non-services	0.45	0.47	0.52	0.47
Services	0.14	0.14	0.15	0.15

Table C2.3. Share of investment from various sectors, used as input in services, USA

	Wholesale and retail trade		Hotels and restaurants	
	1972	1977	1972	1977
Manufacturing				
low-tech	0.08	0.08	0.07	0.07
medium-tech	0.38	0.46	0.25	0.39
high-tech	0.01	0.04	0.02	0.05
Other non-services	0.43	0.32	0.58	0.37
Services	010	0.11	0.08	0.12

	Transport and storage		Communication	
	1972	1977	1972	1977
Manufacturing				
low-tech	0.25	0.26	0.00	0.00
medium-tech	0.31	0.28	0.03	0.05
high-tech	0.23	0.24	0.30	0.34
Other non-services	0.14	0.14	0.47	0.37
Services	0.07	0.08	0.20	0.25

	Finance and insurance		Real estate and business services	
	1972	1977	1972	1977
Manufacturing				
low-tech	0.16	0.18	0.17	0.14
medium-tech	0.36	0.27	0.46	0.41
high-tech	0.08	0.15	0.05	0.10
Other non-services	0.25	0.25	0.08	0.07
Services	0.15	0.15	0.25	0.28

	Community, social and personal services	
	1972	1977
Manufacturing		
low-tech	0.04	
medium-tech	0.09	
high-tech	0.14	
Other non-services	0.65	
Services	0.09	

Table C2.4. Share of investment from various sectors, used as input in services, UK

	Wholesale and retail trade				Hotels and restaurants			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.08	0.08	0.12	0.12	0.05	0.43	0.22	0.26
medium-tech	0.40	0.46	0.30	0.21	0.18	0.13	0.15	0.07
high-tech	0.08	0.06	0.21	0.24	0.13	0.05	0.04	0.04
Other non-services	0.36	0.32	0.35	0.33	0.54	0.28	0.57	0.59
Services	0.08	0.08	0.02	0.11	0.09	0.12	0.02	0.04

	Transport and storage				Communication			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.23	0.23	0.11	0.05	0.01	0.02	0.00	0.02
medium-tech	0.32	0.33	0.43	0.36	0.03	0.02	0.05	0.08
high-tech	0.13	0.13	0.18	0.13	0.32	0.40	0.77	0.76
Other non-services	0.20	0.26	0.25	0.39	0.13	0.12	0.07	0.03
Services	0.11	0.04	0.04	0.07	0.51	0.44	0.12	0.10

	Finance and insurance				Real estate and business services			
	1968	1979	1984	1990	1968	1979	1984	1990
Manufacturing								
low-tech	0.07	0.04	0.00	0.00	0.02	0.03	0.22	0.07
medium-tech	0.13	0.14	0.06	0.10	0.09	0.30	0.14	0.26
high-tech	0.20	0.05	0.28	0.32	0.04	0.21	0.16	0.23
Other non-services	0.51	0.70	0.65	0.50	0.74	0.38	0.46	0.36
Services	0.08	0.07	0.01	0.07	0.11	0.07	0.02	0.08

	Community, social and personal services			
	1968	1979	1984	1990
Manufacturing				
low-tech	0.03	0.03	0.04	0.04
medium-tech	0.05	0.08	0.09	0.09
high-tech	0.07	0.09	0.13	0.14
Other non-services	0.75	0.73	0.73	0.65
Services	0.10	0.07	0.01	0.09

Table C2.5. Share of investment from various sectors, used as input in services, France

	Wholesale and retail trade					Hotels and restaurants				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.09	0.09	0.08	0.06	0.03	0.04	0.06	0.06	0.04	0.04
medium-tech	0.37	0.37	0.38	0.38	0.29	0.17	0.17	0.25	0.30	0.27
high-tech	0.06	0.07	0.08	0.13	0.08	0.03	0.04	0.06	0.09	0.08
Other non-services	0.42	0.40	0.37	0.36	0.52	0.70	0.67	0.57	0.47	0.52
Services	0.08	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.10	0.09

	Transport and storage					Communication				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.15	0.18	0.09	0.09	0.09	0.03	0.02	0.02	0.02	0.01
medium-tech	0.40	0.34	0.38	0.42	0.47	0.08	0.06	0.05	0.06	0.04
high-tech	0.04	0.08	0.13	0.11	0.13	0.49	0.49	0.48	0.51	0.40
Other non-services	0.39	0.39	0.37	0.35	0.28	0.39	0.41	0.43	0.38	0.53
Services	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02

	Finance and insurance					Real estate and business services				
	1972	1977	1980	1985	1990	1972	1977	1980	1985	1990
Manufacturing										
low-tech	0.01	0.01	0.02	0.02	0.02			0.01	0.01	0.01
medium-tech	0.02	0.01	0.06	0.04	0.04			0.01	0.02	0.03
high-tech	0.02	0.02	0.22	0.19	0.23			0.03	0.06	0.11
Other non-services	0.86	0.86	0.64	0.69	0.66			0.82	0.79	0.70
Services	0.09	0.10	0.06	0.05	0.06			0.12	0.12	0.15

	Community, social and personal services				
	1972	1977	1980	1985	1990
Manufacturing					
low-tech	0.05	0.08	0.07	0.04	0.04
medium-tech	0.12	0.12	0.13	0.11	0.12
high-tech	0.30	0.33	0.37	0.46	0.41
Other non-services	0.42	0.37	0.32	0.28	0.31
Services	0.12	0.12	0.12	0.10	0.09

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